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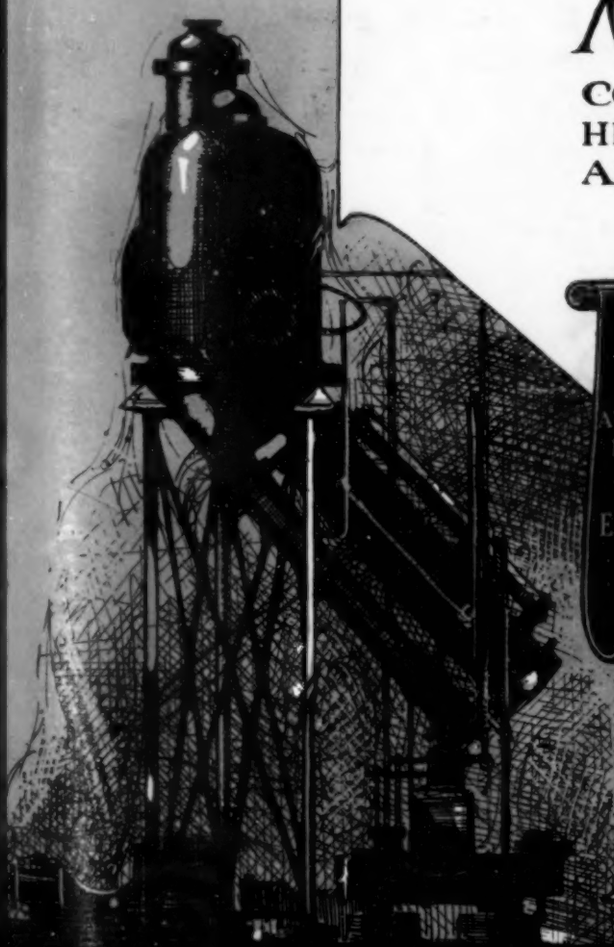

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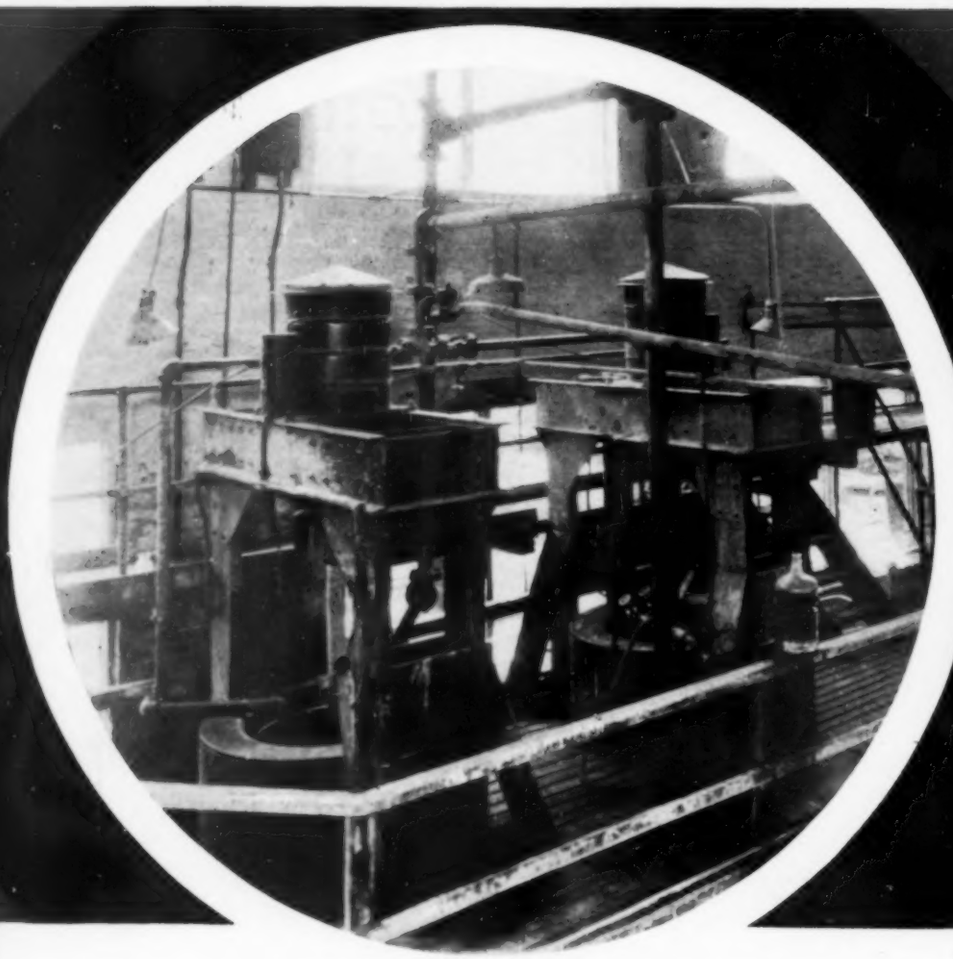

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Chemical & Metallurgical Engineering is the successor to *Metallurgical & Chemical Engineering*, which, in turn, was a consolidation of *Electrochemical & Metallurgical Industry* and *Iron & Steel Magazine*. The magazine was originally founded as *Electrochemical Industry*.

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CHEMICAL & METALLURGICAL ENGINEERING

H. C. PARMELEE
Editor

Volume 34 | New York, April, 1927 | Number 4

1902-1927

Twenty-five Years of Militant Journalism

IT HAS frequently been noted that the first quarter of the twentieth century was the most productive twenty-five years in history with respect to industrial research and development. Within that period science and engineering reached their highest commercial application and yielded marvels of accomplishment compared with which the seven wonders of the ancient world were commonplace. If the history of *"Chem. & Met."* has not been exactly coincident with the first quarter of this century, its twenty-five years of existence cover so great a part of that period as to have given it an opportunity to witness and record the evolution and most momentous achievements in the realm of chemical engineering.

History acquires significance in proportion to our comprehension of the motives animating the actors in the drama of the world's work. It gains sympathetic interest when we know something of the hopes and aims, ambitions and ideals of the men behind the scenes as well as before the footlights. Inspiration flows from intimate insight into human endeavor, the struggle to overcome obstacles, the growth of large enterprises from small and humble beginnings. Hence the builders of today may well occasionally ponder the founders of yesterday in grateful recognition of their pioneer work.

Thus it is with *"Chem. & Met."* on the occasion of its twenty-fifth birthday. We look back momentarily on the personalities that laid the foundations of the present structure, to get a glimpse of their vision and courage. For no institution is established in the absence of those qualities, neither does it survive to a career of usefulness and service.

What did the founders of *"Chem. & Met."* see in 1902 that warranted their venture in the publishing business? Primarily a young but vigorous electrochemical industry, centered at Niagara Falls, blazing a pioneer trail that

promised to lead to developments of great importance. It was a small group of men, mostly electrical engineers, that sensed the publishing possibilities in that industry and subsequently persuaded a publisher to their point of view. Their activities resulted in the closely interwoven development of a professional society and a technical magazine.

For several years prior to 1902 Carl Hering of Philadelphia had been compiling for *Electrical World* the "Digest of Current Electrical Literature." Requiring the services of an assistant in 1899 he engaged E. F. Roeber, a young German who had come to this country in 1894 and who was a trained scientist and engineer and a skilled linguist. In the course of their association together Hering and Roeber discussed electrochemical developments with other men, notably J. W. Richards and C. J. Reed, and ultimately proposed the organization of a technical society in this field. There followed in the spring of 1902 the formation of the American Electrochemical Society, the career of which has been contemporary with that of *"Chem. & Met."* With those already mentioned, W. D. Weaver, then editor of *Electrical World,* was a charter member of the society and an active participant in the publishing venture that was launched a little later. The historical details of the organization of the society are related in another article in this issue.

E. F. ROEBER

C. J. REED

J. W. RICHARDS

With the technical society well established, the leaders responsible for its organization sensed the need of a publication that should serve as an exponent of the new electrochemical industry. There was no current literature on the subject and some medium was necessary for the dissemination of ideas and exchange of information. The logical line of action was through W. D. Weaver, editor of *Electrical World,* to James H. McGraw, its owner and publisher. It was first proposed that Mr. McGraw establish a new magazine that should also be the official organ of the new society, but the latter suggestion was not favorably received. It is worth recording that even at that early stage Mr. McGraw recognized as a sound publishing policy the necessity of maintaining industrial magazines independent of outside affiliations of an official character. Accepting the wisdom of his view the proponents of the idea still urged Mr. McGraw to enter the electrochemical field because it was wholly unoccupied and promised an exceptional opportunity for success and service.

A new publishing venture is not lightly to be undertaken. Enthusiastic suggestions can easily be made without a knowledge of the business risks involved. In this case, however, Mr. Weaver, himself an editor, occupied a point of vantage between the publisher and those who proposed the idea. He was able not only to visualize the industrial publishing possibilities but also to appraise the ability of the men on whom success would depend with respect to editorial excellence. His counsel and advice were helpful in reaching a final decision.

As a result of many deliberations Mr. McGraw incorporated in 1902 the Electrochemical Publishing Co. with J. W. Richards as president, and in September of that year began publication of *Electrochemical Industry* with E. F. Roeber as editor. For the first nine months of its career the magazine was published in Philadelphia, but on June 1, 1903, the offices were removed to New York. In announcing the removal Dr. Roeber observed editorially that "New York has become the seat of nearly all of the leading technical journals of the country, as well as of most of the national engineering societies." He further stated that by publishing in New York the new magazine could "in the highest degree discharge its functions by keeping constantly in touch with the men alongside of the facts—those who make the history of the industries of this country."

Success was accorded the new magazine from the beginning. Its sponsors were alive and progressive. Its editorial pages were virile and its technical contents were of a high order of merit. Discussion of vital topics was lively and interesting. Within two years the editorial scope had outgrown the narrow restrictions of the original title, and in January, 1903, the name of the magazine was changed to *Electrochemical & Metallurgical Industry.* Before that time Doctor Roeber had found it necessary "to pass beyond the bounds of the strictly electrochemical field, and to take account of new chemical and metallurgical developments with which electrochemical products may have to compete, or which may react in some essential way on that industry." His mind was alert to changing conditions and his editorial policy was always evolutionary.

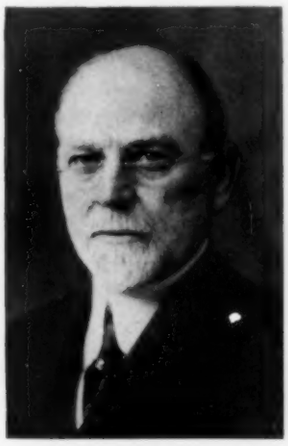
With continued growth and influence the editorial scope of the magazine was enlarged to cover the broad field of "the industrial applications of chemistry and metallurgy, and more particularly those of an engineering nature." This policy was reflected in January, 1910, by adopting the name *Metallurgical & Chemical Engineering.* The broad field of chemical engineering was then recognized by Doctor Roeber and expressed editorially in this language: "Managers and engineers of

ore concentration plants, of cyanide works, of metal smelters, of refineries, as well as manufacturing chemists and chemists engaged in engineering practice in industrial establishments of all kinds, are more or less interested in the same processes—in crushing and grinding, concentration and separation, drying and evaporating, filtration, calcination, combustion, furnace operation, fusion, welding, in the measurement and control of temperatures, in chimney draft and forced draft, and in a hundred other lines of work."

In line with this policy of expansion, western ore metallurgy was included in the editorial scope, and on March 15, 1910, H. C. Parmelee joined the staff as Western editor with headquarters in Denver. This establishment of a Western editorial office was in harmony with the idea of "keeping constantly in touch" with industrial developments. Under this policy the magazine continued to enjoy a large measure of success, and in January, 1913, it was formally taken into the McGraw Publishing Co. by purchase of all the stock of the Electrochemical Publishing Co., the owner until that time.

W. D. WEAVER

CARL HERING



JAMES H. MC GRAW
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Monthly publication of the magazine was maintained from the beginning until September, 1915, when semi-monthly issues appeared. This change in frequency of publication was in harmony with an evolution that had been taking place for some years, resulting in "the emancipation of the metallurgist from the mining engineer, the dissociation of the chemical engineer from the chemist." With the growing importance of these professional groups came the necessity of covering "more intensely and more completely the well defined field" of the magazine in a manner impossible with monthly publication.

During the next seven years the editorial character of the magazine was dominantly metallurgical, in keeping with the trend of American industrial development. Even a casual glance through the volumes published during the period reveals the swiftly moving panorama of research and development, invention and progress that characterized all phases of metal recovery and production—ore dressing, hydrometallurgy, smelting and refining. Precious, base and rare metals received appropriate attention, nor was there neglect of electrometallurgy and electrochemistry on which the magazine was originally founded. It was during this period also that the future growth and importance of chemical engineering was forecast and reflected by a generous sprinkling of articles of that character.

The latter part of this period was fraught with events of fateful significance to the publication. Doctor Roeber's health began to fail early in 1917. In June of that year he gave up active editorial work and retired to a sanitarium for a long period of rest and recuperation, but failed to recover and died on Oct. 17, 1917. His passing was most untimely. He was but 50 years of age and at the height of his career. Out of the obscurity of a clerkship in a New York bookstore he had risen to a position of leadership in technical journalism and had established standards of editorial excellence marked by courage and vigor. He wrote with authority and produced a magazine that was unique among technical publications.

Doctor Roeber was German born but was in process of naturalization at the time of his death. How sore a trial the World War proved to him was never known save to his intimate associates. Possibly it hastened his death. Nevertheless his American patriotism never failed and he wielded a vigorous pen in the allied cause. Shortly after the declaration of war by the United States he wrote under the caption "Patriotism in Chemistry" as follows: "We must stand by the President without thought of party or politics and we must be ready to serve with hearts and heads and hands and fortunes. . . . The first requirement is chemical and metallurgical organization. . . . Chemists who can do productive work in making munitions should be restrained from enlisting to serve with the colors. It is patriotism turned up-side-down for a young man who is familiar, for instance, with nitration processes to march behind the band. . . . The chemists of the United States have suddenly become, in large measure, the trustees of her safety. Let us not fail."

Doctor Roeber was not the phlegmatic type of German. He was always bubbling over with enthusiasm and this characteristic was reflected in everything he did. He was idealistic, aggressive and wholly unhampered by tradition. Hence he loved to speak of "militant journalism" and inspired his associates with that spirit. Typical of his thoroughness was the manner in which he acquired facility in writing English. The editorials in the *New York Evening Post* commanded his admiration and he set them up as a standard of perfection. Each day he translated one of these editorials into the best German he was capable of writing and laid it away for 30 days. At the end of that period he re-translated it into the best English he knew and then compared his product with the original, carefully noting his deficiencies. Thus for a time he schooled himself and gained an enviable com-

mand of written English that was in marked contrast to his spoken word.

In March, 1917, another important event transpired that greatly strengthened the position of this and other engineering magazines owned by the McGraw Publishing Co. and the Hill Publishing Co. This was the consolidation of the two companies into the McGraw-Hill Publishing Co., publishing ten magazines in the engineering field. Aside from achieving mere bigness, which is a contributing factor to success in our modern industrial system, this consolidation increased facilities for editorial service not otherwise possible. Ultimately the new environment necessitated a change in editorial policy to avoid conflict with *Engineering & Mining Journal* in the field of Western ore metallurgy. Accordingly *Metallurgical & Chemical Engineering* ceased its activity in that direction and later gave particular attention to physical metallurgy.

The illness of Doctor Roeber necessitated new editorial direction of the magazine and in the summer of 1917 Ernest E. Thum joined the staff as associate editor. He added strength to the metallurgical character of the publication and upheld the high editorial standards already established. In the ensuing six years he covered Western ore metallurgy for a time, and later gave the magazine an enviable reputation as an exponent of physical metallurgy. In the fall of 1917 Mr. Parmelee returned to the editorial staff, having been absent for a year serving as president of the Colorado School of Mines. In October, 1918, he was appointed editor.

Due largely to the impetus given to chemical engineering in industry during the war, the years immediately following the armistice witnessed unusual growth and progress in American industries based on chemical engineering practice. A study of existing conditions and probable future developments determined the publishers to make a fourth, but minor, change in the name of the magazine, and in July, 1918, *Chemical & Metallurgical Engineering* succeeded it predecessors in name. No marked change ensued in editorial policy because for some time prior to the change in name chemical engineering had received major attention. Within a year, however, industrial progress and development were proceeding at such a rapid rate that adequate service could not be given by semi-monthly publication, and in October, 1919, weekly publication was begun. This was continued until March, 1925, when monthly publication was resumed.

In this scanty survey of the history of *"Chem. & Met."* it may strike the casual reader that changes have been so frequent as to suggest instability and uncertainty of editorial policy. On the contrary such changes indicate shifts in the industrial scene that are faithfully reflected in the publication. The established order of yesterday is out of date tomorrow. Last year's model is soon antiquated. Evolution is the only permanent order in nature. Thus an editorial policy, if it be virile, is a flexible thing. It must of necessity be dynamic. Occasionally stock must be taken of trends in the industry which the publication serves, for it is a vital part of that industry and not merely an isolated factor in the publishing business. Progress and change become vocal through its pages, and the man in Maine benefits thereby as promptly as the man in California.

Such is the spirit that has animated the editors and publishers of *"Chem. & Met."* A review of the thirty-three volumes published during the past twenty-five years will reveal numerous shifts of emphasis on phases of industrial problems pertinent to conditions of the time. At one moment scientific research may be most important in a given industry. Later the engineering problems of production may demand consideration, and these in turn be overshadowed by the economic phases of sales and distribution. With solution of the major problems and reduction to routine practice, emphasis can be shifted to new developments in the ever changing kaleidoscope of science and engineering in industry. It was the early recognition of this fact that led Doctor Roeber to write in January, 1905, "A technical journal to fulfill its functions to the highest degree, must grow with the industry which it endeavors to serve and adapt itself to changing conditions." It was in no spirit of apology, but rather of leadership, that changes were foreseen and made.

H. C. PARMELEE
Editor

S. D. KIRKPATRICK
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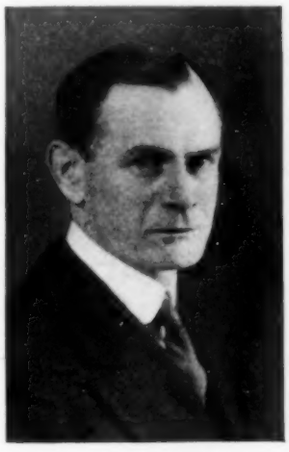
G. L. MONTGOMERY
Assistant Editor

C. TYLER
Assistant Editor

Another method of giving editorial emphasis to timely subjects has been to concentrate on a single theme in a single issue. This is in recognition of the fact that even a high plane of editorial excellence may become monotonous unless relieved by an occasional mountain peak of accomplishment. The career of *"Chem. & Met."* is marked with an appropriate number of such elevations, emphasizing the need of putting our industries on a scientific basis, eliminating waste, combating cor-

rosion, meeting conditions of severe service, etc. Latterly, the need of statistical service has been recognized, and in 1924 we began publication of an annual statistical and economic survey of the chemical industry. This industry has never been noted for its quantitative data on production, distribution, stocks and prices, and hence *"Chem. & Met."* has undertaken to put these modern tools of business into the hands of executives.

These comments will serve to illustrate and explain the evolution of this magazine to its present position as the exponent of chemical engineering in industry. In the ebb and flow of controversial opinion on chemical engineering *"Chem. & Met."* has endeavored to establish



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Market Editor

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Assistant Editor
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P. D. V. MANNING
Assistant Editor

PAUL WOOTON
Washington Correspondent

a constructive editorial policy leading to a definite goal. Hence in March, 1925, the editorial decks were cleared for action with the following declaration:

"Chem. & Met." is a magazine of opinion written for that large group of men who are responsible for production and administration in the chemical engineering industries. Thus its major editorial field is the technology and economics of those industries; the goal of its efforts is production efficiency and business success. On this platform the magazine becomes a common meeting ground for the fabricator of chemical engineering equipment, the producer of commodities that form the raw materials or finished products of various industries, the buyer and seller, the engineer, the plant operator, the business executive.

"We believe in chemical engineering in industry; in the intelligent application to production methods of chemical, physical and mechanical principles. We believe in the efficiency, economy and ultimate profit of engineering methods; in the displacement of manual labor by mechanical handling; in the use of modern engineering equipment and automatic control; in the development of continuous processes wherever possible. We believe in the direct and beneficent influence of these factors on national prosprity and individual standards of living.

"We believe in extensive and intensive application of the engineering method—the determination of facts and their honest interpretation—not only in research, development and production, but also in those more neglected but equally important phases of business—purchasing, marketing, management and financing. We believe in thus forestalling the element of surprise in business; in eliminating the casual; in substituting knowledge for 'hunch.'

"We believe in the conservation of material resources through intelligent use; in the elimination of waste from our industrial life and the conversion of byproducts into useful and profitable commodities. As exponents of technical publicity we believe in the open exchange of technical information, knowing from observation and experience that industrial progress is thereby advanced by leaps and bounds. We abhor and expose the industrial charlatan as the enemy of honest chemical engineers.

"Finally, and fundamentally, we believe in chemical engineering education and industrial research as two great factors that will banish empiricism and rule-of-thumb from industry and place it on the firm foundation of science and engineering."

As a byproduct of their work the editors of *"Chem. & Met."* have engaged in various activities related to chemical engineering. The story of the inception of the American Electrochemical Society has already been mentioned. Doctor Roeber was one of its founders and a staunch supporter throughout his editorial career. Within a ten-year interval both he and Mr. Parmelee served as presidents of that organization. Another society activity to which the magazine has lent its editorial support is the study of chemical engineering education under the auspices of the American Institute of Chemical Engineers. This has been regarded as a matter of such fundamental importance as to warrant the time and attention that have been devoted to it. Closely related to the educational work has been the organization and production of chemical engineering text and reference books on a plan originally conceived in the editorial staff and actively supported by its members.

Two editors have successively directed the editorial activities of this magazine, and in the twenty-five years of its existence exactly twenty-five men have at various times been in the editorial organization. Of these, eight comprise the editorial staff today. This is neither the time nor place to appraise the value of the work of those who have made *"Chem. & Met."* nor is it fitting to attempt to apportion credit for editorial accomplishment. Nevertheless it is clearly recognized that E. F. Roeber was the dominant spirit during fifteen years of what he liked to call "insurgent engineering journalism." Evolution to anticipate and meet industrial needs was his guiding principle, as it is of the present editors and publishers.

Old and New Conceptions of Chemical Engineering Education

By William H. Walker

Consulting Chemical Engineer, Los Angeles, Calif., Non-resident Professor of Chemical Engineering, Massachusetts Institute of Technology.

WHEN *Chemical and Metallurgical Engineering* first made its appearance twenty-five years ago, four-year courses of study leading to the degree of Bachelor of Science in Chemical Engineering had been an established fact in a few educational institutions for ten years or more. The number of men graduating from these courses was, however, relatively small, and as it seems to us now the welcome they received from the chemical public was not particularly cordial. It is probable that the experience of the Massachusetts Institute of Technology as it relates to the teaching of chemical engineering was practically that of other institutions offering courses in that subject, and therefore a consideration of the difficulties encountered there may represent the whole.

In 1902, after somewhat more than ten years of experience in the teaching of what was then called chemical engineering, it was evident that either the expected demand for chemical engineers had not materialized, or that the men as then graduated did not have the qualifications expected of them. At this time the writer was asked by the president of the Institute of Technology to make a survey of the situation, and to report to the faculty such changes in the curriculum in chemical engineering as would enable it to meet more completely the demands of the times. Two causes for the relatively unsatisfactory results then obtaining soon became apparent. First, the men being graduated were not chemical engineers except in name, and second, the chemical manufacturing public was not asking for nor receiving the type of men that could and would be of the greatest assistance to it.

Chemical engineering as a separate course of study found its origin in the realization on the part of those professors engaged also in technical work, that many industries needed men who had a better training in chemistry than it was possible for those students taking mechanical engineering to acquire in the time devoted to this subject. In New England special attention was directed to the textile industry in its many phases, pulp and paper, leather and the shoe industry, and such manufacturers as depended upon chemical as well as mechanical processes. The president of the Institute stated in one of his annual reports that the graduates of this new course were "engineers with an acquaintance with chemistry." Presumably he meant a bowing acquaintance. At any rate this described the chemical engineer of 1902.

Although the field was ripe for the harvest, those in charge did not at this time perceive that in the processes depending upon chemical change, it was the chemical forces that must be understood and directed, and that this could be intelligently done only by one who had not "an acquaintance with chemistry" but, on the contrary, a thorough knowledge and training in chemistry. Mechanical and electrical means are constantly employed to direct and control chemical forces, and therefore the principles of mechanical and electrical engineering are a necessary part of the chemical engineer's education; but he must be first and last thoroughly trained in chemistry or he can never become a chemical engineer worthy of the name.

The first great step in advance, therefore, was taken when institutions offering chemical engineering courses changed their curricula so as to provide for a thorough training in chemistry as a fundamental science, entirely apart from its applications.

The second difficulty which presented itself in more adequately meeting the needs of the then rapidly growing chemical industries was the attitude of the employers themselves. Each manufacturer demanded a man who had specialized in his particular field, and who had a detailed knowledge of its operations and products. This resulted in undue specialization in the curricula of the early courses in chemical engineering, with the inevitable result that both chemistry and physics as sciences were sacrificed to make room for the so-called practical courses. The graduates of such courses were too frequently, as might have been expected, a disappointment when they attempted to solve the industrial problems with which they were confronted. Take, for example, the manufacture of soap. The colleges could not teach more regarding soap making than was known by the able superintendent of a soap plant. Hence such a graduate could contribute but little to what the superintendent already knew. What the soap maker really needed was a man thoroughly grounded in chemistry and physics with such a training in the application of these sciences as to enable him to make this knowledge an integral part of his thinking equipment (such as the multiplication table is), but without any detailed knowledge of soap making. This man in co-operation with a practical superintendent rapidly acquired a knowledge of the process, and this when superimposed upon his scientific foundation and engineering training evolved the man the industry was looking for.

Such an analysis of the real necessity of the industries was not readily received by employers of chemically trained men in the early days of the present century. But as the above facts became self evident to the practical business man, it was possible for the educational institutions to drop the highly specialized courses, and replace them by more thorough courses in chemistry and physics on the one hand, and on the other to introduce courses supplying a general knowledge of those unit operations which in one form or another make up the chemical manufacturing plant.

A tremendous help to teachers of chemical engineering was the appearance in 1904 of that monumental two-volume work by George E. Davis of England under the title "Handbook of Chemical Engineering." Although not treated fundamentally from a mathematical point of view, Davis here set out for the first time those unit operations from which, by proper co-ordination, a chemical process is built up, and crystallized in the minds of many educators the meaning of chemical engineering.

The development of chemical engineering education has in its detail followed very closely upon the changing conception of what constitutes a chemical engineer, and a selection of those factors which have contributed most to its present status will of necessity vary with the experience of the chronicler. For example, in the opinion of the writer, chemical engineering education was greatly stimulated by the entry of Dr. Milton C. Whitaker into this field as a professor in Columbia University. Dr. Whitaker had had an intensive experience in industrial and factory management, and brought to the teaching of chemical engineering points of view not hitherto enjoyed by most college professors. Propelled by his virile personality his ideas of the business responsibility which the chemical engineer must recognize in his work, that "correct appraisement of values and costs" which the engineer must be able to make, soon permeated the teaching of many institutions to its great advantage.

Everyone is loud in his praises of the value of mathematics not only as a cultural study, but as a working tool of the practicing engineer. Yet the promptness with which the average chemical engineer forgets all his mathematics beyond algebra is appalling. Hence the entry of a mathematical physicist and chemist into the teaching of chemical engineering was also a stimulus to more thorough work. Although Barbet and Sorel in France, and Young in England had done much in laying a mathematical foundation for distillation and rectification, and Hausbrand of Germany had contributed materially to a more complete understanding of the principles of drying and evaporation, it was in the appearance of Dr. Warren K. Lewis as a teacher of chemical engineering that the educational profession obtained a man who could master from a purely theoretical standpoint the principles of mathematics, chemistry and physics, and who at the same time possessed the ability and inclination to apply these same theoretical conceptions of science to the solution of industrial problems. For a man to whom calculus is as familiar as the alphabet, whose physical chemistry is literally at his finger tips, and whose engineering common sense constantly dominates his most theoretical speculations, the teaching of chemical engineering was a most happy vocational selection. Add to these qualifications a contagious enthusiasm which permeates every activity, and a generous helpfulness that knows no bounds, and the profession of teaching receives a leaven which can leaven a very large loaf.

But an education in science does not alone make an engineer. The etymology of the word gives a key to the type of man thus described. In addition to a knowledge of science, he must possess the ability to use this knowledge in the conception, design, construction and operation of chemical processes and plants. This requires a training in that type of work which develops this ability. In the early days of chemical engineering education this training was left entirely to the industrial plant

W. H. WALKER

As an exponent of chemical engineering in teaching and practice, Dr. Walker has had an unusually active and successful career. During the war he was commanding officer of Edgewood Arsenal with the rank of Colonel, C.W.S., and received the D.S.M. for his services.

Marceau

A. H. WHITE

Specializing in chemical technology at Zurich under Lunge, Prof. White returned to the University of Michigan in 1897, where he has been professor of chemical engineering since 1911. During the war he served as Lt.-Col. in the Nitrate Division of the Ordnance Dept.

M. C. WHITAKER

Chemical engineering education received a great impetus through the work of Dr. Whitaker at Columbia University. Later he gained distinction for his organization of production in the Welsbach Co. and the U. S. Industrial Alcohol Co. He is now a consulting engineer.

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W. K. LEWIS

As head of the department at Massachusetts Institute of Technology Dr. Lewis has made conspicuous contributions to the teaching of chemical engineering. He is joint author of important texts on the subject and is also prominent as a consultant.

Geo. H. Davis

which employed the young graduate. So far as special knowledge and training of any one operation is concerned, this is still true and must remain so. But by the judicious development and employment of engineering and research laboratories, the more broadly trained man as now supplied the industries was slowly developed.

THE SPIRIT of research which in the early days of the twentieth century made such rapid progress in this country was soon reflected in chemical engineering curricula, especially in graduate courses. Possibly the immediate and marked success which attended the efforts of Dr. W. R. Whitney in organizing and developing the research laboratory of the General Electric Company at Schenectady, is to be credited with much of the support which early was offered to the introduction of laboratories and personnel devoted to research in institutions offering engineering courses. The pioneer work of Dr. Robert Kennedy Duncan in the systematic application of science to the solution of industrial problems in an organization devoted to this object, first at the University of Kansas and later at the University of Pittsburgh, and the establishment of the Laboratory of Applied Chemistry at the Massachusetts Institute of Technology, Cambridge, are examples of this activity which has had a profound effect on chemical engineering education.

The University of Cincinnati made a real contribution to chemical engineering education when, in 1907, it introduced its system of co-operation with industrial organizations by which "students may be given their engineering training and industrial experience concurrently with their academic education, both under the guidance of the university." This system has now been in operation for sufficient time to have fully proved its usefulness and well deserves the careful study of all educators in the chemical engineering field.

An important study of the co-operative method of engineering education has recently been completed by the Society for the Promotion of Engineering Education and the results have been published in the *Journal of Engineering Education* for March, 1927. Advantages and disadvantages are discussed with respect to the student, faculty, school and industry, and numerous opinions are cited. The committee in charge of the investigation concludes that "neither all students nor all institutions are best served by a single uniform standardized type of program," but it believes that "In this diversified field co-operative training seems unmistakably to have its proper place. The indications are that its particular function and peculiar merit is in training men for the operation of industrial enterprises. That many young men pursuing the co-operative courses will become highly competent designers or researchers and that many all-resident students will attain to positions of importance in the operating side of the industry is undeniable, but it is probable that the co-operative program tends, on the average, more directly to prepare students to adjust themselves promptly to the requirements of administration and operation."

In 1916 the Massachusetts Institute of Technology placed in operation a plan of post-graduate training in chemical engineering, also co-operative in its character, known as the School of Chemical Engineering Practice, which differs radically from that of the University of Cincinnati in its essential characteristics. This school is the result of a plan conceived and formulated by Dr. Arthur D. Little, a life member of the corporation of the institute. Well organized stations have been established in a few industrial centers, with such close co-operation with certain industrial chemical plants that the factory of the company becomes a laboratory for the student. The school is a post-graduate course and is characterized by the fact first, that the students devote their entire time to work that is designed as educational without reference as to whether it is or is not productive, and they receive no pay from the industries concerned. Second, owing to the method of instruction used and the type of work undertaken, it is necessary that the students shall have received their fundamental education before attempting this work. Third, in order that the instruction be truly intensive and individual only ten to twelve students are taken in a single group and placed in the direct charge of an assistant professor with a full instructor as his assistant. The writer has closely observed the results of this plan and believes that no better training for a chemical engineer has yet been suggested.

A third type of co-operation which has within the last ten years contributed much to chemical engineering education is that between the manufacturers of chemical factory apparatus and the educational institutions. A splendid example of this spirit of mutual helpfulness is found in the laboratory devoted to evaporation and other vapor pressure phenomena at the University of Michigan. Philip B. Sadtler and the Swenson Evaporator Company were among the early and generous contributors to this work. Not only do valuable chemical engineering data result from the operation of such a laboratory, but education in chemical engineering is greatly stimulated thereby.

In 1920 the number of educational institutions offering instruction in what each chose to term chemical engineering had increased to over 80, and curricula of the most diverse character existed. The American Institute of Chemical Engineers appointed a committee to study the situation, and to report to the Institute recommendations looking toward raising the academic and professional standing of education in this subject. Under the efficient chairmanship of Dr. Arthur D. Little this committee made a comprehensive study of the field, and in 1922 reported to the Institute its findings and recommendations. These were most enlightening and have proved very helpful to those charged with the responsibility of conducting courses in chemical engineering.

ONE of the recommendations of this committee was that the American Institute of Chemical Engineers should arrange for a meeting of those who are interested in improving the education of our chemical engineers. Such a meeting took place in New York in March, 1926, under the chairmanship of H. C. Parmelee, and developed a discussion of many points of importance which must of necessity be helpful in clarifying our ideas of chemical engineering education.

In this general development an undescribed amount of help has come from men active in the chemical industries; but it is obviously impossible at this time to do more than to record the grateful acknowledgment of their services by the teaching profession.

American Industrial Progress Through Scientific Research

By Edward R. Weidlein, Sc.D.

President, American Institute of Chemical Engineers; Director, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

INDUSTRY is both a being and a becoming, and so is industrial research. Industrial research may be evaluated either from a purely monetary standpoint, both to the industrialist and the scientist but primarily to the industrialist, or from the broader viewpoint of its importance to the community. Even a cursory study of the needs of life and of the foundation upon which civilization, and particularly democratic civilization, is built reveals the fact that science is necessary for progress. It is a component part of the things that civilization, through the centuries, has brought about. It is the hope of the future. Science is the greatest modern creator of new wealth and the greatest practical agency of democracy—the greatest equalizer of our time. As such a creator of new wealth and new resources, science and its continual development vitally affects taxation and the cost of living, first, by creating new wealth to help share the burden, and, second, by making the necessities of life constantly better and cheaper.

E. R. WEIDLEIN

In his role of director of the Mellon Institute of Industrial Research of the University of Pittsburgh, E. R. Weidlein maintains the closest contact with industry and has the broadest knowledge of its technical problems. His inspiration for industrial research came from Robert Kennedy Duncan who was teaching chemistry at the University of Kansas when Weidlein was a student there, and who was later instrumental in establishing the Mellon Institute.

It is impossible in an article of this type and scope to give credit to all industries, scientists and engineers who have contributed so admirably to the development of our present-day civilization, and therefore attention will be restricted to those industries and directors of research who have kindly supplied information, in consequence of a direct request from the editor of *Chemical & Metallurgical Engineering*.

Let us first turn our attention to an industry that was born and brought into commercial usefulness within the last twenty-five years. Dr. L. V. Redman, who has had an important part in the development of the phenol-resin industry, has supplied the following account of its growth through research.

Beginning with Dr. Baekeland's discovery of a proper method of controlling the production of phenol resins, their subsequent hardening under heat and pressure, and their increased strength when fillers are used, particularly fibrous fillers, these discoveries have made possible the application of phenol resins in technology in the widest and most varied manner. They have made possible the rapid and cheap production of distributor heads and rotors for automobile ignition. The accuracy of dimensions with which these phenol resins can be molded and their permanence of shape under elevated temperatures, such as one gets under an automobile hood, has made their application very extensive in the automobile industry. In addition to distributor heads and rotors, coil housings, bells for motors, insulation strips, and punchings of all sorts and varieties are used in the automobile of today. Also, the timing gear in many automobiles is made of laminated canvas-base phenol-resin material.

Phenol resins are rapidly revolutionizing the grinding wheel and waterproof sandpaper industries and bid fair to revolutionize completely the method of oil-well drilling, since carborundum, held together with a phenol resin, cuts through sand many times more rapidly than steel bits.

Some of the more spectacular and less voluminous uses created for phenol-resin products are dentures for false teeth, non-heat producing grinding instruments for the dental trade, glaze for porcelain ornaments, handles on coffee percolators, pencil barrels and fountain pen barrels.

Another very prominent branch of manufacture is the rubber industry, which has been developed enormously in the last twenty-five years. In 1900 rubber products factories were few, and the chemist as a forward-working research man was rare in the industry. Since then, however, factories and research laboratories have grown, until today rubber stands out as one of our most important industries. Dr. W. C. Geer has ably presented the development of this industry in an article printed elsewhere in this issue which covers both research and operating advances.

The American Telephone and Telegraph Company carries on its research and development work for the Bell system through the joint agency of two groups: one, the department of development and research of the American Telephone and Telegraph Company, and the other, the Bell Telephone Laboratories. The work of these two groups is closely correlated and is in effect a single operation under one executive. Dr. F. B. Jewett, who has played such an important part in the development and expansion of the research activities of this great corporation, has recounted some interesting information to strengthen our contention that research is of high value to the community.

The elaboration and development of the telephone systems of remote control by relays, switches, etc., have made commercially possible in large and small centers of population the use of mechanical automatic systems, involving machine switching central offices and private branch exchanges, dial telephones, and all their associated apparatus.

Carrier telephone systems have been perfected, using the principle of modulated high frequency currents in apparatus meeting the exacting requirements of telephone operation.

Radio apparatus and systems have been developed not only for broadcasting transmission, but more essentially for telephone communication; the result has recently appeared in the introduction of the transatlantic radio telephone link between the land systems of England and America.

Fundamental studies of sound, music, hearing and speech, thermionics, and the relation between electrical and mechanical impedances have been intensively pursued. The present high quality of telephone transmission is one result already attained. Numerous devices in other fields, such as the audiphone for deaf people, the audiometer for the measurement of deafness, the artificial larynx, the orthophonic victrola, the vitaphone, public address systems, and other devices, to a greater or less extent owe their existence to these basic studies.

The research on photoelectric effects, combined with the studies previously mentioned, and the development of special apparatus, has produced the transmission of pictures over telephone lines.

The development of permalloy, an alloy of nickel and iron possessing extremely high permeability at low field strengths, has had important consequences in submarine cable development (where it is used for continuous inductive loading, and has speeded transmission five-fold), as well as in telephone and associated apparatus.

The development of printing telegraph equipment has added a highly perfected and commercially important system of communication.

THE testimony of Dr. W. R. Whitney and Dr. L. S. Hawkins lends additional support to our contention that research is of inestimably high economic value. Their resume of the work of the research laboratory of the General Electric Company is very concise but impressive in what it records. Drawn tungsten made the tungsten lamp robust and relatively inexpensive, and so made it capable of universal application. A portable X-ray outfit brought X-rays to the bedside of the patient. The oil-immersed dental outfit made radiography safe for dentist and patient. The latest developments of the laboratory are the high power cathode ray tube and the atomic hydrogen welding. We are all familiar with the General Electric's advances in the fields of lighting, radio, X-rays, alloys, insulation, calorizing, and rectification—progress that has been made possible by scientific research of the most painstaking and thorough type, conducted by scientists and engineers of high ability and actively supported by the executives of the company.

The research department of the Westinghouse Electric and Manufacturing Company is likewise covering a broad field of scientific investigation, as outlined by S. M. Kintner.

The work that has been done in the Westinghouse laboratories by Yensen, Brace and others on magnetic steels represents a prominent accomplishment and has tended to improve materially the practice of the steel companies from which the Westinghouse Company's requirements are purchased. These men have found what it is possible to expect from very high grade materials and have evaluated the influence of each of the several impurities generally occurring therein.

The autovalve lightning arrester is another outstanding achievement of this department. There were found the underlying principles, which resulted in determining certain factors that were essential to the proper design of the arrester. This arrester is at present in very general use and has proved satisfactory in service.

The development of a satisfactory chemical that can be employed for the removal of oxygen in the air that is breathed into large oil-insulated power transformers resulted from a very extended study of a number of materials that offered promise for this purpose. At present there is between one and two million kilowatt capacity of transformers equipped with this system, and it is growing in popularity as experience is had with it in service.

The investigation of a number of vacuum devices and principles has resulted in the production of a superior type of photo-electric cells, photo-electrically sensitive glow tubes, and other forms of relay devices, which are proving of great service for control purposes and other places where contacts must be eliminated.

THE bringing of aluminum into the ranks of the cheaper metals has been wonderful and chemistry has been the pathfinder. Dr. Francis C. Frary and Dr. Earl Blough state that one of the notable results of recent research is the Hoopes process of electrolytically refining aluminum. By this process the Aluminum Company of America has been able for the first time actually to carry out on a large scale the electrolytic refining of the molten metal in a molten bath, and can produce aluminum of purity as high as 99.97 per cent. The high resistance to corrosion shown by this high purity metal makes it seem probable that it will eventually find important industrial applications where a light-weight metal of such a type is needed.

The work of F. M. Becket and of other scientists and engineers of the Union Carbide and Carbon Corporation shows clearly the sympathetic attitude of our great corporations toward research.

This corporation's research is conducted at a central laboratory in Long Island City, and in other experimental laboratories under jurisdicton of the respective subsidiary companies at Buffalo, Cleveland, and Charleston, W. Va. A development laboratory operating on the scale of a small producing plant is also maintained at Niagara Falls. As a result of many years' work in these laboratories, the Corporation is firmly convinced of the value of coordinated research, on fundamental principles as well as on commercial problems, and hopes to expand this field of activity.

The production of alloying metals by the Electro Metallurgical Company was the direct result of industrial research applied to metallurgy. Largely as a result of the research of this company the number of alloying metals available in commercial quantities has been considerably expanded. Several metals which, though obtainable twenty-five years ago, commanded such high prices that their use was very limited have been so cheapened by the development of new manufacturing processes that their use has been greatly extended. Much of present-day industry is dependent on these new and cheaper metals.

On the base of very low-carbon ferrochromiums rests the entire high-chromium steel industry. The chemical engineer is already using these steels extensively because of their resistance to corrosion. Within a few years he will be using even more extensively reaction apparatus dependent on them for strength at high temperatures and resistance to oxidation by hot gases. Thus the steady tendency toward the use of higher pressures and temperatures for the more economical conduct of chemical processes or for the manufacture of new products, which has been hampered through lack of safe materials of construction, can be expected within the coming years to make new strides through the availability of these steels. The Electro Metallurgical Company's research has contributed largely to the development of these steels. It has also contributed to industry high-chromium steels having unique resistance to abrasion, especially where corrosive conditions must also be combatted.

Mr. W. H. Bassett, of the American Brass Company, points out still other research accomplishments in the field of metallurgy.

The application of the metallurgical microscope to non-ferrous metals and alloys was begun just about twenty-five years ago, and resulted in the understanding and control of the hardening of copper and copper alloys by cold working. It also made possible the clear comprehension of grain growth and its control, as well as the control of physical properties by heat treatment.

Researches into season cracking revealed the causes of the spontaneous cracking of certain alloys and also methods for prevention and control.

Researches into the effect of small amounts of impurities in metals and alloys have resulted in the obtaining of metals in a very high state of purity and marked improvement in quality and usefulness. This work has required research into methods of chemical analysis and of spectrographic analysis.

Studies on the structure and corrosion of condenser tube alloys have greatly improved the quality and length of service to be obtained from condenser tubes, for both marine and power-station service.

C. E. K. MEES

Director of the research laboratory of the Eastman Kodak Co. since 1912 Dr. Mees has been prominent in the field of photochemistry. He was educated at London University and engaged in the manufacture of photographic plates in England before coming to this country.

PAUL D. MERICA

Metallurgical research has marked the career of Dr. Merica. He was in the Bureau of Standards 1914-1919, and has since been director of research for the International Nickel Co. His work on corrosion is outstanding and has resulted in numerous technical papers.

W. R. WHITNEY

Among directors of industrial research none has achieved greater recognition than W. R. Whitney. Under his supervision the research laboratories of the General Electric Co. at Schenectady have become world renowned. He has directed the laboratories since 1901.

Dr. Paul D. Merica, who likewise has been a progressive factor in the metallurgical field, has related some of his activities in recent years with the International Nickel Company.

During the past five or six years a great deal of research and development work has been done concerning the effect of combinations of nickel and chromium in cast iron and the industrial applications of such alloyed iron products.

Another series of researches, carried out mostly by the International Nickel Company, and which has been going on for several years, is the study of the corrosion-resistance of Monel metal and of nickel.

Among process researches may be mentioned the study of the operation of depositing nickel electrolytically. By studying the effect of current density, temperature, hydrogen-ion concentration, as well as of certain other variables, it has been possible to improve the electrolytic deposition of nickel, particularly with respect to the purity of the resulting product. Electrolytic nickel now on the market contains approximately 99.9 per cent nickel (plus cobalt). It is very free from copper, iron, carbon and sulphur.

Heat-resisting alloys have been developed almost entirely within the past twenty-five years through the researches of many individuals, starting with Placet and Marsh, resulting in a series of alloys having remarkable mechanical properties as well as chemical stability at high temperature. These alloys are ordinarily of the nickel-chromium or nickel-chromium-iron type and have been the means of opening up to the engineer new opportunities in high-temperature construction in the field of combustion engineering, heat-treating, annealing, metallurgical roasting, etc.

One can safely say that the art of electroplating has been gradually developing into a science within the past twenty-five years and particularly within the past five or ten years, due especially to the researches of Dr. W. Blum, of the Bureau of Standards, of Prof. O. P. Watts, University of Wisconsin, and many others.

G. W. Thompson and Dr. R. L. Hallett have given the following brief account of their chief achievements:

During the past quarter century, progress has been made along many new lines and useful materials and processes have been discovered and developed which were not known at the beginning of the period. The research department of the National Lead Company has had an active part in some of these developments, among which are the use of titanium oxide in paint, the invention of Frary bearing metal, and the development of the Thompson-Harris process for the separation of the so-called "white metals."

The development of large scale scientific and practical paint testing at the Sayville experiment station of the National Lead Company has been one of the valuable contributions of the company's research department. This research department has also taken an active part in work in connection with factory improvements and the perfecting of the National Lead Company's processes and products.

The liquefaction of the so-called permanent gases as well as the fractionation of the liquefied gases were first developed industrially by the Linde company approximately twenty-five years ago for the express purpose of producing oxygen from liquid air on a commercial basis. As might be expected, the results obtained during this development period lacked many of the refinements that are used in the art today and which have been worked out during the last decade as a result of a large amount of physico-chemical and chemical engineering research. This research has made possible the following advances in the art of rectification of liquefied gases: the reclamation of a larger amount of the oxygen content from the air than was previously possible; the production of nitrogen suitable for industrial purposes; the simultaneous production of pure oxygen and nitrogen; and the separation of argon, neon, and helium from air on a commercial basis.

The mass of valuable fundamental physical and chemical data developed in the course of research in perfecting these processes has found ready application in the extraction of helium, as well as other components, from natural gas. The technic evolved has also provided the scientific basis on which the Linde Air Products Company, during the World War, was able to build its suc-

cessful helium production units at Forth Worth, Texas. Numerous refinements in the first helium plant have been accomplished by continued research; but the original engineering designs, although distinctly novel in type, were an actual commercial success, largely because the earlier research had dealt with fundamentals. This war-time achievement, the conversion of a chemical curiosity to a commercial balloon gas, is a striking example of the adaptability of well planned industrial and scientific investigation.

THE RESEARCH department of the National Carbon Company, Inc., as reported by H. D. Batchelor, has produced from carbon, the most common chemical element next to oxygen, all manner of things essential to the commercial world. Among the most important of these products are carbon electrodes which range in size from huge elements forty inches in diameter, nine feet long and weighing three to four tons, for use in steel and other metallurgical furnaces, to tiny pencils of carbon one-eighth inch in diameter and two inches long, used in small dry cells. Another and perhaps not so well known form is that of activated carbon—the last defense beween our soldiers and the deadly gases used in warfare.

This development work represents another interesting picture: the progressive transformation of the old abandoned street arc light to the latest thing in motion-picture projection, to the last word in tremendously high-powered searchlights used by our Army and Navy, and recently to the therapeutic carbon arc—the latest and perhaps one of the most important recent additions to medical science.

Over a quarter of a century ago the flashlight, another form of light, was produced by these research laboratories in recognition of the need of an easily portable electric light. Here again the original element has been developed from a dim, barely visible light to a high powered searchlight of several thousand beam candle power. These laboratories have also developed the dry cell in all forms from an original laboratory toy to one of the essential elements of the electrical industry. Investigation and research have increased many fold the electrical capacities of this product.

A recent contribution of the Union Carbide and Carbon Research Laboratories is a methane detector of two distinct types. These two devices developed by chemical and physical research provide a portable indicator which can be used to give warning of the presence of explosive gases in coal mines or elsewhere. In this instance the industrial research work of the corporation finds itself employed in a distinctly humanitarian service.

TWO of the most important tools for metal working today are the oxy-acetylene welding and cutting torches. This equipment has been made really valuable by an unusually broad co-operative effort among several companies. The Union Carbide Company contributed through large-scale industrial research on the production of calcium carbide. The Prest-O-Lite Company developed the method of bottling acetylene dissolved in acetone, thus making the gas portable and available in smaller quantities than warrants the installation of generators. Not the least important phase of this research was that concerned with safety in the compression and transportation of acetylene and its companion gas, oxygen, as a result of which these two gases are now widely distributed by all the usual means of transportation.

IN THE FIELD of organic chemistry, the Carbide and Carbon Chemicals Corporation has applied intensive research methods to isolate in pure form the various constituents of the huge hydrocarbon resources of the country and to use these materials as the basis of intricate synthetic processes. This work is the result of intensive research begun at Mellon Institute by Dr. George O. Curme and his associates. The results of this research have made available in large quantity and at low cost a variety of commercially valuable aliphatic organic chemicals, distinct in origin as well as in application from the synthetic chemical products heretofore generally known.

A principal product of these efforts is ethylene glycol, which has been offered to industry for the first time, after having been known since the early days of chemistry only as a chemical curiosity. Ethylene glycol is now widely used in explosives manufacture and as an antifreeze material for automotive engines; it is also finding numerous new uses to supplement the inadequate supplies of glycerol and is further serving purposes entirely new in the arts. The ethers of glycol are ideal solvents for nitro-cellulose lacquers and in the rapidly expanding lacquer industry they are introducing qualities indispensible in their nature.

The pure hydrocarbon constituents of natural hydrocarbon mixtures have also found many valuable and interesting uses. For example, ethane, propane, isobutane, and normal butane have been found to have special physical properties making them desirable as refrigerating gases. Commercial propane has contributed a form of fuel gas with widespread application in household, laboratory, and factory heating problems. Thus an ever-increasing number of products is being produced from these hydrocarbon raw materials, and it is apparent that an industry of large proportions is in the process of being established on the fundamental research which has been conducted in this field.

WHILE referring to organic solvents it is important to mention achievements of Dr. M. C. Whitaker, of the United States Industrial Alcohol Company.

The production of high grade, pure cologne spirits from molasses, which is fully competitive with the alcohol made from grain, is now done as a continuous distilling operation without the use of charcoal or chemical treatment and the accompanying expensive redistillation operation.

The U. S. Industrial Alcohol Company has solved the problem of producing anhydrous alcohol by the continuous distillation process, resulting in large production at low cost. This process is not only in use in the United States, but also in Continental Europe, England and Australia.

In the chemical field Doctor Whitaker and his associates have contributed to the development of new processes and new products in which alcohol is used as a raw material. They have developed and manufactured acetic acid from alcohol for chemical purposes on a very large scale. The manufacture of ethyl acetate by an efficient and continuous process, using all grades of dilute solutions from acetic acid, including vinegar, has also been worked out. Another accomplishment is a continuous

process for the production of anhydrous ethyl acetate by an azeotropic distillation process and without the use of chemicals. By its large available production of anhydrous ethyl acetate, this company became the only American producer of large tonnages of ethyl aceto-acetate, which is now supplied to dye and pharmaceutical manufacturers. A new process for the direct production of the higher esters, such as oxalic, lactic, citric, tartaric, and phthalic, has been evolved. In this direct esterification method no intermediates are required. The process is based on an application of the azeotropic principle during esterification. The manufacture from alcohol of a high-grade ethylene for anesthesia and of a commercial grade of ethylene for cutting and welding has also resulted from research. Finally, note should be made of the processes for the production of chemically pure normal propyl, iso-propyl, iso-butyl and amyl alcohols, and of processes and large-scale operation for the recovery of potash salts and ammonia from molasses distillery waste.

NO MORE striking illustration of the important relation of science to industrial progress and public welfare can be found than in the very successful research of the E. I. duPont de Nemours & Company, of which a condensed picture is presented by Dr. Charles M. A. Stine.

Among the outstanding achievements of this company's research men is the development of much safer methods of manufacture of high explosives. The development of machinery for carrying out many of the operations in the manufacture of high explosives, and the standardization and improvement of the processes of manufacture, has freed this industry from many of the risks which attached to manufacturing operations of this type years ago. It is possible that the use of high explosives, while very wide and very important in the development of the industries of this country is still not so much a matter of general information as to insure an appreciation of the great progress which has been made in this industry. The development of the so-called permissible explosives for use in coal mines, and of dynamite which is not merely low-freezing but practically non-freezing, are accomplishments which has contributed in a very important fashion to increasing safety in the use of industrial explosives.

Then, too, the improvement of propellent powders to give greater accuracy and reliability is another outcome of the continued systematic research which the du Pont company has carried on in this highly specialized field.

One of the company's early developments, outside of the manufacture of explosives, was the production of a coated textile, which has a wide variety of uses. The quality and beauty of this material has been steadily improved, and new possibilities for its employment have been opened up by the continuous study of the numerous factors which influence its properties. Parisian ivory is another material to which constant attention has been paid for the purpose of improxing its properties and varying the beautiful effects which may be obtained.

A large variety of paint and varnish products and heavy chemicals are manufactured by the du Pont company, and form the subject of constant study, not only for the sake of maintaining the high quality of these products, but in order to improve them and develop new products. In connection with the organic chemical industry, the du Pont company has been successful in developing a large number of dyes, some of them new, some of them radical improvements. Not only dyes, but other compounds of an organic nature for improving the curing of rubber, have been produced in the du Pont research laboratories. They have also made some important contributions to the development of disinfectants for seeds.

The large industrial developments of the du Pont company in the manufacture of rayon and cellophane, of photographic film, and of industrial alcohol, and in the fixation of atmospheric nitrogen are well known.

DR. C. E. K. MEES, who has contributed so much to the wellbeing and progress of the photographic industries, has communicated the following brief account of several research results:

One piece of work of which everybody is now aware is the development of the Cinē-Kodak process, including the invention of the reversal process and the working out of the necessary apparatus, a system by which the films daily received from amateurs at the present time can be processed. The whole of the system of amateur cinematography marketed by the Eastman Kodak Company was originated in the research laboratory.

A piece of research work which has proved very fruitful in practical results, but which has no direct relation to the work of the company, was the development of a method of electroplating rubber from latex solution. This was studied originally in order to find a method of covering photographic apparatus with rubber. The results obtained were so satisfactory and novel that the process was eventually sold to the Anode Rubber Company, Inc., for exploiting in many directions which were not originally contemplated.

DR. E. C. SULLIVAN, of the Corning Glass Works, points out some of the principal achievements in the field of glass technology.

The development of low expansion glasses used for laboratory ware, baking ware, line insulators, chemical manufacture, lamp-making, etc.

The development of potash-free lead glass for incandescent lamp bulbs when the outbreak of the World War shut off imports of potash, and later development of non-lead glass for incandescent lamp bulks, which has made possible tank melting and manufacture of bulbs by the automatic machine.

The development of lens design and high transmission colors for railroad semaphore signals.

Glasses for absorbing or transmitting various selected wave lengths, including X-rays, ultraviolet and infra-red. Among these products is a glass comparable with quartz glass in ultraviolet transmission.

Silicate refractories, such as tank blocks, cast in moulds from the molten material.

Representative of research done in the schools are the following investigations carried out in the University of Michigan: Heat transfer and evaporator design; gas absorption; electrodeposition of metals; mechanism of combustion in automobile engines; petroleum distillation and equipment design; season cracking of brass and factors affecting properties of metals at elevated temperatures; purification of coal gas; instantaneous carbonization of crushed coal; causes of the disintegration of concrete and gypsum structures when exposed to moisture; dimensional changes in steel with heat treatment; and design of steel springs.

* * * * *

The history of industry shows clearly that within the last fifty years, and largely within half that period, manufacturing practice has advanced with a speed incomparably greater than at any previous time. Empiricism has given way to industrial research, or the application of experimental method, as manufacturing has kept pace with the advancement of science in general. Great progress in technologic knowledge has come from the infusion, through industrial research, of chemistry, physics, biology, and engineering; and technology, or systematic industrial practice, can proudly boast of many conquests that deserve to be called marvelous.

Electrochemical History Recorded In Society's Activities

By Colin G. Fink

Secretary, American Electrochemical Society
Head Division of Electrochemistry, Columbia University

AS WE LOOK back over the records of the American Electrochemical Society we appreciate more and more that it was due to the high ideals, untiring and unselfish efforts, and sincere interest and enthusiasm of three men, Carl Hering, E. F. Roeber and J. W. Richards, that made the society not only possible but made it one of the most potent influences throughout the world.

The first official title of this journal was "Electrochemical Industry" and its early volumes record in striking fashion the "classic" period of American electrochemistry. The same engineers and scientists who launched this journal back in 1902 were among the six who founded the American Electrochemical Society some months previous. Professor Joseph W. Richards of Lehigh University, who had been elected first president of the society, was likewise president of the Electrochemical Publishing Co. which originally published this journal. The first editor was E. F. Roeber and a faithful first contributing editor was Dr. Carl Hering of Philadelphia.

On October 19, 1901, a letter signed by Hering, C. J. Reed, Richards, Roeber, Professor Samuel P. Sadtler and Dr. Wm. H. Wahl (then Secretary of the Franklin Institute) was sent to 34 "engineers, chemists and scientists." This letter read in part as follows:

> "The rapidly growing importance of the subject of electrochemistry, and the want of suitable occasions in this country for the discussion of papers and questions pertaining thereto by those specially interested, have suggested the advisability of founding a national electrochemical society."

Those interested in the project were invited to meet at the Engineers' Club, Philadelphia, on the evening of Friday, November 1, 1901. It was indeed a most enthusiastic gathering that took place that evening. Electrochemistry was in its very prime. The accomplishments along both theoretical and practical lines were attracting world-wide attention. Ostwald at Leipzig was publishing the foundations of a new science of chemistry. Moissan's fundamental electric furnace experiments suggested vast possibilities on a commercial scale. Acheson and Tone at Niagara Falls were making graphite and carborundum in ton lots. Charles S. Bradley and D. R. Lovejoy were "fixing" atmospheric nitrogen. Edison had launched his new nickel-iron storage battery and Roeber was expounding the theory of its operation. E. R. Taylor had recently started the large-scale production of carbon bisulphide in his electric furnace at Penn Yan, New York, and aluminum, "the silver queen of the electrolytic cell" was selling at 35c. a pound as against $1.50 ten years previous.

The inaugural convention of the new society took place at Philadelphia on April 3, 1902. Richards was elected president, C. J. Reed, "the prime mover in the organization of the society," was elected its first secretary and Pedro G. Salom, of storage battery fame, treasurer. None of the officers received a salary, a custom which has persisted to this date. Reed was succeeded by S. S. Sadtler and in 1907 Richards was made secretary, a post which he held until his death on October 12, 1921. Commenting on the inaugural convention and upon the founding of the American Electrochemical Society, Dr. Wilder D. Bancroft, an enthusiastic member from the very start, recalls that at the time (1901-1902) "the American Chemical Society was not organized in divisions, and had an educational qualification for membership which kept out many electrical engineers and others who were interested in electrochemistry, though not primarily from the chemical end. Consequently a self-appointed committee met with a committee from the American Chemical Society to see whether electrochemistry could be developed under the auspices of the American Chemical Society. The committee from the A.C.S. apparently knew very little about electrochemistry and cared less. It refused to make any recommendations to the Council of the A.C.S., and suggested that the electrochemists wait a year before taking any action. That was preposterous, so we went ahead with the formation of the American Electrochemical Society."

How well we remember, and with keen pleasure too, the many lively discussions, and at times heated arguments, that followed the presentation of a learned treatise or technical paper at one or the other of the many conventions of the American Electrochemical Society. It was the close scrutiny of results reported and the free interchange of opinions that hastened the advance and progress of electrochemical science and art. In one of the front rows of the auditorium sat Dr. Hering and Dr. Roeber, ready to challenge any statement or record that did not appear in accordance with theory or with practice. Meanwhile, Richards was making a few rapid calculations to show that if the proposed electric furnace had been constructed on a spherical design basis, instead of the box type, an increase of 8 per cent in efficiency would have resulted—and if, furthermore, the outside walls of the furnace had been cov-

ered with "aluminum" paint there would have been an additional saving of 10 per cent in power input.

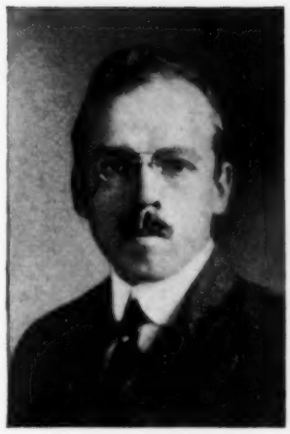
At one of these early meetings Charles F. Burgess and his associates recorded their fundamental experiments on electrolytic iron, now produced commercially in America and in France, and we heard of the systematic research that soon resulted in the "Burgess battery." Whitney was transforming "carbons" into "gems" and triumphed in his researches at Schenectady. Sperry made a few chalk scratches on the blackboard and proved that motion and velocity were mere relevant conceptions. Baekeland discoursed on his new phenol condensation products for electrical insulation and the princess' necklace. Bancroft and Lidbury would be waiting for the discussion to reach a point where the author of a paper felt convinced that his attitude and data were correct—then introduce a new angle into the debate and cause the author to feel less certain of his results and conclusions. Lawrence Addicks in his characteristic oratorical style would lay down the fundamental laws for efficient large-scale production of pure electrolytic copper. FitzGerald of Niagara Falls proved that the electric furnace was simpler and more easy to operate than any fuel-fired hearth. P. G. Salom revealed the mysteries of the lead storage battery and foretold its glorious future. Hutton of Manchester showed an astounded audience how large masses of electrically fused quartz could be made into bowls and pipes. Kahlenberg of Wisconsin cited interesting, though often perplexing, experiments and held firmly to his belief that the theories of Arrhenius, of Ostwald and of Nernst were not as generally applicable as the staunch supporters, Lash Miller, Sam Tucker, Frary and others maintained. Crosby, Gillett, Baily and Hering each proved to the audience that for electric brass melting, the arc furnace, the resistor type and the induction furnace, were each superior and more efficient than the others.

C. F. BURGESS

Leaving the University of Wisconsin in 1914, where he had established courses in electrochemistry and chemical engineering, Dr. Burgess has since engaged in electrochemical research, development and manufacture. He has been active in the affairs of the American Electrochemical Society and is an extensive contributor to its literature.

C. G. SCHLUEDERBERG

One of the few industrialists to be honored with the presidency of the American Electrochemical Society, Mr. Schluederberg held that office in 1922. He has also been active in other capacities, notably on the membership committee. He is general manager, George Cutter Co., a subsidiary of the Westinghouse Electric & Manufacturing Co.



C. G. FINK

Secretary of the American Electrochemical Society since 1921, Dr. Fink has given unsparingly of his time to the society's activities and is largely responsible for its lively condition. He is professor of electrochemistry, Columbia University, and has a long and successful record of industrial research.

F. A. LIDBURY

Active in the affairs of the American Electrochemical Society since 1903, Mr. Lidbury has contributed to the gaiety, good management and technical excellence of the society and served as president in 1914. He is president of the Oldbury Electrochemical Co., one of the first of the Niagara Falls electrochemical industries.

But in the midst of all this discussion and debate the feeling of good fellowship has always prevailed. The society has always been a very democratic one. The members are the ruling body; they nominate and elect their officers, select the places of meeting and choose the papers for discussion. There is but one class of members. The young college graduate is on an equal footing with the engineer or professor of many years standing.

Roeber, Richards, and Hering, have all three passed into the realms beyond. The healthy state of the society today is due in large measure to the continued interest of members such as Acheson Smith, C. G. Schluederberg, F. A. J. FitzGerald and A. T. Hinckley.

W. D. BANCROFT

A charter member of the American Electrochemical Society, Dr. Bancroft has been one of its most consistent supporters. He was president in 1919 and has been a large contributor to the *Transactions*, both as original author and critic. He is professor of physical chemistry at Cornell University.

W. LASH MILLER

President of the American Electrochemical Society in 1912, Dr. Miller played a prominent part in the early history of the society, which he joined as a charter member on April 3, 1902. For many years he has held the post of professor of physical chemistry and has directed research in the University of Toronto, Canada.

Chemical Engineering Contemporaries

Progress in chemical engineering during the past twenty-five years represents the sum total of advances made by many men in the technology of many processes and industries. The achievements of some of those who have contributed notably to this progress are briefly recorded here. Others, perhaps of equal or greater merit, are noted elsewhere in this issue.

George D. Rosengarten

FEW AMERICAN chemical industries can boast of a hundred years' existence, yet the house of which Dr. George D. Rosengarten is vice president is now in the 109th year of its career. Established in Philadelphia in 1818 by Farr & Kunzie, the business was just five years old when the first George D. Rosengarten became interested in it, later to assume the control that has since been vested with the Rosengarten family. H. R. Rosengarten directly succeeded his father, and from 1905 to 1921 the firm of Powers-Weightman-Rosengarten Co., was in the hands of H. R. Rosengarten and his four sons.

Dr. George D. Rosengarten has recently been honored by the election to the presidency of the American Chemical Society—a distinction merited by many years of leadership and service.

F. G. Cottrell

WHEN the Perkin medal was awarded to Frederick G. Cottrell in 1919 high recognition was given to his principal achievement in chemical and metallurgical engineering—electrical precipitation of dust- and fume-laden gases. The first installation was made at a contact sulphuric acid plant of the Hercules Powder Co. at Pinoli, Calif., for the precipitation of sulphur trioxide fumes. But the process found more extensive use in metal smelters and refineries and in cement plants.

With his ability in scientific research Dr. Cottrell embodies in an unusual degree the qualities of idealism and unselfish public service. It was from such motives that he established the Research Corporation to administer his patents. His long record of work in the scientific bureaus of the Government also exemplifies his spirit of service. He was successively chief metallurgist and director of the Bureau of Mines, and is now director of the Fixed Nitrogen Research Laboratory. He graduated from the University of California in 1896 and took his doctorate at Leipsic in 1902.

Oscar H. Wurster

AS ONE of the few chemical engineers who have specialized in the soap and fat and oil industries during the past twenty years, Oscar H. Wurster has accumulated an enviable experience in this important branch of technology. Fifteen of these twenty years—from 1907 to 1919—were spent in the operation of plants producing soap, glycerine and fatty acids and in the development of processes in these plants which included the M. Werk Company of Cincinnati, Lever Brothers, Ltd. of Toronto, Morris Bros. of Chicago and the Louisville Soap Co. of Louisville, Ky. Then followed three years of work with William Garrigue & Co. of Chicago.

In 1921 he joined with the late Walter Sanger in founding the firm of Wurster & Sanger which has been closely identified with many of the modern advances that have taken place in soap making, glycerine purification and the distillation of fatty acids.

Richard K. Meade

TWENTY-FIVE YEARS ago Richard K. Meade as chief chemist for the Edison Portland Cement Co., had made his first connection with the cement industry, and then he succes-

G. D. ROSENGARTEN

F. G. COTTRELL

O. H. WURSTER

R. K. MEADE

sively served in the same position with the Northampton Portland Cement Co., and the Dexter Portland Cement Co., finally becoming general manager of the Tidewater Portland Cement Co., in 1909. Consulting practice begun in 1907, has extended to most of the prominent cement, lime and plaster manufacturers. With the late J. H. Payne, Mr. Meade developed the process of recovering lime from alkali waste using the rotary kiln which he also introduced for many other furnacing operations. Plants for the production of potash from feldspar and its recovery from cement kiln gases were built and operated during the war.

From 1904 until 1910, Richard K. Meade was editor of *The Chemical Engineer* and in that position worked courageously for and took the initiative in organizing the American Institute of Chemical Engineers. This accomplishment, which he regards as the most constructive achievement in his entire professional career, was carried on with the assistance of Dr. McKenna, Dr. Frerichs and others.

Walter Herbert Fulweiler

CHEMICAL engineering in the manufactured gas industry is a development of the past twenty-five years and, for that whole period, Walter Herbert Fulweiler has been one of its leading practitioners.

Upon graduating from the University of Pennsylvania in 1901, Mr. Fulweiler became chemist for the Philadelphia Gas Works, the first of a series of steps leading to the positions of Chemical Engineer of the United Gas Improvement Co. in 1920, and Chemical Engineer of the U. G. I. Contracting Co. in 1923. During this period, he made numerous developments, including the use of water gas tar in highway construction and wood preservation, the recovery of toluol without the removal of the benzol and solvent fractions from the gas, and the production of toluene and anti-knock fuel from light petroleum distillates.

One of Mr. Fulweiler's major interests has been testing and he has made many improvements in gasworks testing methods. He is the author of numerous papers on gas and kindred subjects, and has served with distinction as president of the American Society for Testing Materials.

George Moore

IT IS NOT always that originality of invention can be definitely attributed to an individual. But in the case of vacuum filtration and George Moore the relation is definitely established. Necessity was the spur to his imagination, and ingenuity marked his first experiment. As in many other industrial operations, trials and tribulations were encountered before commercial success was achieved.

In 1901 the Sunshine gold mine in Utah was cyaniding a talcose ore which, on crushing, yielded 60 per cent of the pulp as slime, difficult to filter and very retentive of dissolved gold. Filtration and washing in plate-and-frame presses was ineffective, resulting in a heavy loss and necessitating some better method of treatment. Mr. Moore experimented with various processes, including centrifugal separation, but without success.

Finally the idea of vacuum filtration occurred to him and he went to the laboratory for a simple experiment. Taking a board about one foot square he attached a wire screen to one side and covered the screen with canvas. On the opposite side he inserted a pipe through a hole in the board and connected the pipe with a bicycle pump adapted to the purpose. The improvised filter was submerged in a tub of slime pulp, and after a few minutes pumping it was withdrawn with a ½-in. cake of slime adhering to the surface of the canvas.

The success of the experiment led to commercial installations.

Alfred L. Webre

MECHANICAL DRAFTING has been the first job of many successful chemical engineers. This, at least, was the start of Alfred L. Webre's career with the John H. Murphy Iron Works in New Orleans, after he had distinguished himself as a student of engineering in Tulane University. Leaving the Murphy works in 1905, Mr. Webre was in successive years instructor in Tulane University and gas engineer for the Fairbanks Morse Co.; in 1907, however, he returned to his original employer as engineering estimator. Since 1921 Mr. Webre has been in consulting practice, his principal clients at present being E. B. Badger & Sons Co. and the U. S. Cast Iron Pipe & Foundry Co. Besides many articles in the technical press, Mr. Webre has written two books, "The Heat Balance in the Cane Sugar Factory," and "Evaporation" in the preparation of which he was assisted by Prof. Clark S. Robinson.

Several inventions, improvements in the art of evaporation, have been granted Mr. Webre, and to him should go credit for devising standardized methods for calculating evaporator problems.

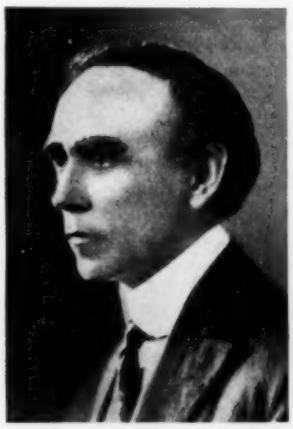
Edward G. Acheson

BEGINNING his career as a chainman on railroad construction. Edward G. Acheson later followed more scientific inclinations that led to conspicuous inventions in electrochemistry. The route lay through Edison's laboratory where one of his experiments produced a material of exceptional hardness. Ten years later he repeated the experiment by placing a mixture of clay and carbon in an iron pot and passing an electric current through the mass. Crystals of silicon carbide, which he named carborundum, adhered to the arc-light carbon used as an electrode. He began manufacture at the rate of ¼ lb. per day and sold the product to lapidaries and machinists. The first sale was of 200 carats at 30 cents per carat. Later the Carborundum Co. was organized and established at Niagara Falls and production reached millions of pounds.

As a sequel to his production of carborundum he discovered that the silicon could be volatilized by heat and that

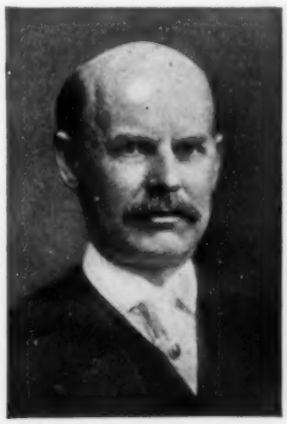
W. H. FULWEILER

GEORGE MOORE



A. L. WEBRE

E. G. ACHESON



Clair Marcellus

graphite remained. Patenting the process, he organized the Acheson Graphite Co. which became a substantial Niagara Falls industry. Continuing his work on graphite he produced colloidal suspensions of the substance useful as a lubricant. Mr. Acheson has received many honors and medals for his inventions and is today an honorary member of the American Electrochemical Society.

Frederick M. Becket

IN THE FIELD of electrometallurgy F. M. Becket has gained a reputation for thoroughness, resourcefulness and successful endeavor that put him in the first rank of his profession. As chief metallurgist of the Electro Metallurgical Co. and vice-president of the Union Carbide and Carbon Research Laboratories, he has been closely identified with the development of the ferro-alloy industry in this country.

Chief among his accomplishments was the reduction of molybdenum and vanadium with silicon, which has been ranked with the aluminothermic reduction process of Goldschmidt. During the war the Government called on him for the production of zirconium and within a few months he was prepared to produce in quantity limited only by the ore supply. His researches on chromium and its combinations with iron have given a great impetus to the use of that metal as a material of chemical engineering construction.

With his attainments in science and engineering Mr. Becket combines sound business judgment that eliminates waste of effort and avoids mistakes or futile investigations. Capacity for organization and the selection of men has enabled him to carry on an unusual amount of research and development.

Frank Ellsworth Dodge

COMING to the coal byproducts industry with a background of ten years' chemical experience in operation and research work, Frank Ellsworth Dodge joined the staff of The Barrett Company in 1900 as superintendent of the Frankford works. During this period, up until 1906, under his supervision, this plant produced all grades of crude and refined benzols, nitrobenzol, nitro-toluol, aniline, toluidine, phenol, cresols, refined naphthalene and other coal tar chemicals.

After a period of six years in which he was engaged as chemist on the utilization of coal gas residuals for the United Gas Improvement and in general consulting practice, Mr. Dodge resumed his connection with The Barrett Company, this time as benzol production expert for the whole company. During this period came the world war and Mr. Dodge's services to the country in assuring an adequate supply of benzol, toluol and similar products used in munitions, proved invaluable. His work consisted largely in devising improved production equipment and improving methods of operation to produce maximum yields.

Mr. Dodge is a native of the state of Vermont and received his education in chemistry at the University of Vermont. At the present time he holds the position of Chemical Engineer with the National Lead Company.

F. A. J. FitzGerald

CLOSELY interwoven with the development of electrometallurgy and electrochemistry at Niagara Falls is the name and career of F. A. J. FitzGerald. After graduating from Trinity College, Dublin University, Ireland, where he was moderator and medallist in experimental physics and chemistry, he came to this country in 1893 and graduated in electrical engineering at Massachusetts Institute of Technology in 1895.

For eight years he was associated with Dr. E. G. Acheson successively in the Carborundum Co. and the Acheson Graphite Co. in chemical control, research and development work. Since 1903 he has engaged in consulting practice and has been particularly identified with the development of the electric furnace. Notable among his developments are the electric zinc furnace, alloy furnaces, and recrystallized silicon carbide of which he was the inventor. His latest achievement is the adaptation of the electric furnace to the ceramic industry.

A charter member of the American Electrochemical Society he has been closely related to its numerous activities. In 1916-17 he was president of the society and has also served as vice-president and manager. As chairman of the publication committee he has been largely responsible for the high quality of the society's publications.

William D. Mount

DATING from 1896, when he completed the development of the application of the Castner process for the electrolytic production of caustic soda and bleaching powder, William D. Mount has been one of the foremost chemical engineers in the alkali industry. For twenty years, until 1918, Mr. Mount was successively general superintendent, general manager, and director of the Mathieson Alkali Works, during which time extensive changes and improvements in the processes and equipment used by this company were effected, and the Bucher process for nitrogen fixation, later taken over by the government, was investigated.

In recent years, Mr. Mount has carried on an extensive consulting practice in the fields of lime, alkali and paper manufacture. He is the holder of numerous patents in these fields, among which the most notable are for continuous, gas-fired, vertical lime kilns; continuous rotary filters of the vacuum and pressure types; and continuous causticization with lime recovery.

Mr. Mount is a native of New York

F. M. BECKET

F. E. DODGE

F. A. J. FITZGERALD

W. D. MOUNT

A. D. LITTLE

GEORGE OENSLAGER

HENRY HOWARD

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Alman & Co

State, having been born at Groton, N. Y., and trained at Cornell University. For many years he has been a resident of Virginia and at present carries on his consulting practice from headquarters at Lynchburg.

Arthur D. Little

IN GENERAL PRACTICE as a chemist and chemical engineer in Boston since 1886, Arthur D. Little has participated in many developments resulting from the application of science to industrial production. First as Griffin & Little, later as Little & Walker and finally as Arthur D. Little, Inc., he has been in consulting practice for forty years. In his early experience he was identified with the paper industry and did much to introduce scientific methods into production processes. Since then his interests have extended broadly into the field of chemical engineering in industry.

Having unusual facility in literary work he has been instrumental in directing thoughtful attention to conditions and problems that lack appreciation or need solution. Thus his "Developing the Estate" emphasized the need of rational use and conservation of the material resources of the country. His "Fifth Estate" singled out for emphasis and recognition "the company of thinkers, workers, expounders and practisioners upon which the world is absolutely dependent for the advancement of science." For some years past his voice has been raised in support of industrial development of the South, pointing out its natural opportunities and resources. Finally he has been not only vocal but effective in organizing and developing chemical engineering education.

George Oenslager

ACCORDING to a competent historian of the rubber industry, the commercial use of nitrogenous organic accelerators in rubber vulcanization began in 1906 and was due to the investigations of George Oenslager. At that time in the laboratory of the Diamond Rubber Co. he made the discovery that aniline oil and other nitrogenous organic compounds greatly shortened the time of vulcanization and simultaneously improved the physical properties of rubber mixtures containing the poorer grades of crude rubber. The economic effect of this discovery and related developments may be measured in millions of dollars saved to consumers of tire and other rubber products, and in additional millions to manufacturers in plant and equipment.

Mr. Oenslager's first technical work was in the pulp and paper industry where he served for ten years. Since 1906 he has been identified with the rubber industry, first with the Diamond Rubber Co. and subsequently with the B. F. Goodrich Co. In 1920-22 he was technical advisor to the Yokohama Rubber Co., Japan. His work has been marked by an unusual degree of precision and accuracy, imagination and persistence. Personally modest and critical of his own efforts, he is not as widely known as his achievements deserve and it has remained for others to capitalize his discoveries.

Henry Howard

LEAVING the Massachusetts Institute of Technology in 1889, where he took a special course in chemistry, mechanical engineering and shop work, Henry Howard started work as chemist for the Merrimac Chemical Co., Boston, and has since been engaged in heavy chemical manufacture. His advancement in the Merrimac company led to the position of superintendent in 1896, and to the vice-presidency from 1902 to 1920. Besides designing and building the early works of the Merrimac Chemical Co., he also designed, built and put in operation the aluminum hydrate works of the Pennsylvania Salt Manufacturing Co. at Natrona, Pa. In 1920 he joined the Grasselli Chemical Co., Cleveland, taking charge of research and development.

His interests are wider, however, than chemical manufacture. An expert yachtsman, he is a member of several yacht clubs. During the war he organized and directed the department of the U. S. Shipping Board which provided and trained personnel for the new American Merchant Marine. He has been active in technical and civic organizations: past president of the American Institute of Chemical Engineers, member of the chemical advisory committee to the Department of Commerce, the National Foreign Trade Council and the National Industrial Conference Board. He is also chairman of the executive committee of the Manufacturing Chemists Association of the United States.

Otto Mantius

LIKE MANY other pioneers in chemical engineering design, Otto Mantius was trained as a mechanical engineer. A native of Germany, he studied mathematics and mechanical engineering in the Universities of Rostock and Hannover, from which he graduated in 1900. Following post graduate study in chemistry in the University of Berlin, Mr. Mantius was connected with a European manufacturer of evaporators and other chemical equipment. In 1906 he came to the United States as consulting engineer for B. T. Babbitt, Inc., and after installing their soap and glycerine machinery he went to Chicago as superintendent of the American Foundry & Machine Co., the builders of Swenson evaporators at that time. The year 1908 found Mr. Mantius as chief engineer and vice-president of the Zaremba Co., with whom he remained until 1915 when he became consulting engineer for the U. S. Industrial Alcohol Co. His

M. H. ITTNER

achievement with the latter was the design and construction of the Curtis Bay plant.

Since 1916 Mr. Mantius has practiced chemical engineering independently, specializing in evaporator design and in the design of complete chemical plants. Two of his outstanding inventions are the inclined and vertical rapid circulation evaporator for foaming and delicate liquors, and the reclamation of waste sulphuric acid, particularly sludge acid from petroleum refining.

Martin Hill Ittner

AS AN ABLE and courageous champion of American chemical industry, Dr. Martin H. Ittner has contributed greatly to technical progress in the manufacture in this country of fine soaps, perfumery and toilet preparations. Serving Colgate & Co. for the last 30 years he has been actively engaged, with the aid of other chemists and engineers, in the development of many products not previously made in the United States. And it has been his privilege to see these same products displace their foreign rivals in many of the world's markets.

But not all of Dr. Ittner's battles have been fought with competitors from overseas. As chairman of the Committees on Industrial Alcohol of the American Chemical Society and the American Institute of Chemical Engineers, he has had to wage a continuous opposition in this country against those who would cripple American chemical industry by cutting off the necessary supplies of one of its basic chemical raw materials.

Dr. Ittner has served the technical and scientific societies in other capacities. He has long been a councilor of the American Chemical Society and in 1922 was chairman of its New York section. He is also a member of the Council of the American Institute of Chemical Engineers and since 1926 has been its national treasurer.

F. L. JORGENSEN

Horton-Guest Studio

F. L. Jorgensen

BORN in Copenhagen and educated in Danish schools, F. L. Jorgensen came to the United States about twenty-five years ago. As a result of his early work in cement plants he became impressed with the necessity of abating the dust nuisance in order to avoid expensive litigation and the cost of buying land adjacent to cement factories.

Accordingly, about ten years ago he backed his judgment and began the manufacture of dust collecting and fume recovering devices. Closely related to this was his development of pneumatic conveying equipment for handling bulky materials. Dust and fume recovery have now been adopted in a wide variety of industrial operations, and in the smelting industry Mr. Jorgensen's method is displacing the old-fashioned baghouse for recovering blast furnace flue dust and metallic oxides. Pneumatic conveying by the high vacuum system has proved especially flexible in handling chemicals and other products that otherwise give rise to undesirable working conditions and material loss.

Personal qualities of imagination and persistence have played a large part in Mr. Jorgensen's contributions to chemical engineering progress.

William H. Nichols

BEGINNING the manufacture of chemicals in 1870 when he was but eighteen years of age, William H. Nichols developed his business until in 1899 he conceived and organized the General Chemical Co. and ultimately became the acknowledged leader of the American chemical industry. The 20-year history of his organization, published in 1919, is dedicated to Dr. Nichols, "who conceived the idea and who as its first president guided its early footsteps and has been its chief adviser and source of inspiration." His record, as given in Forbes' biography in "Men Who are Making America," is one of strict business integrity, initiative and resourcefulness. An outgrowth of his chemical business was the Nichols Copper Co., a pioneer in copper smelting and electrolytic refining.

Dr. Nichols was educated at Polytechnic Institute, Brooklyn, and New York University, and both of these institutions have since been the beneficiaries of his generous financial support. Due to his early technical training at these schools he brought to bear on chemical manufacture the exact methods of science in place of the empiricism that marked the industry when he entered it. He has been the recipient of many honors at home and abroad, and is today chairman of the board of the Allied Chemical and Dye Corporation.

W. H. NICHOLS

Carbon P. Dubbs

BORN in Franklin, Pa., in the very heart of the oil country of that day and in the continuous sight of oil derricks and refineries, it is natural that C. P. Dubbs should devote his life work to the chemical and technologic problems of the petroleum industry. In so doing he was following in the footsteps of such pioneers as Henry Dubbs, whose patent on decolorizing petroleum had been issued in 1875, and of Jesse A. Dubbs, whose several oil refining patents date from 1889.

For more than 25 years Mr. Dubbs has been actively engaged in the chemistry and distillation of petroleum, the refining of oil, the manufacture of asphalt and the cracking of heavy oil into gasoline. He has directed his energy not alone to the chemical problems of petroleum but also has had personal management and active charge of refineries at Pittsburgh; Los Angeles;

C. P. DUBBS

H. H. DOW

Maricopa, Calif.; Independence, Kan.; and Chicago, Ill. His signal achievement, both scientific and industrial, is the development of the Dubbs cracking process which is in commercial operation in the principal refining centers of the world. He is vice president of the Universal Oil Products Co., Chicago, owners of the cracking process that bears his name.

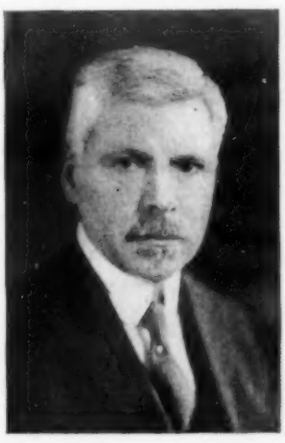
Mr. Dubbs is one of those rare individuals who has the inventive faculty with the scientific acumen to see a problem through and the practical sense of carrying it on to commercial realization.

Herbert H. Dow

BY THE PURCHASE IN 1890 of a brine well in Michigan for $100 Herbert H. Dow laid the simple foundation of what subsequently became the Dow Chemical Co. Mr. Dow had graduated from the Case School of Applied Science in 1888 and after teaching one year had turned his attention to the manufacture of bromides, first at Canton, Ohio, and later at Midland, Mich. Years spent in costly experimentation resulted in developing new processes of manufacture. He patented his blowing out process for bromine in 1889, but it was not until 1892 that he put potassium bromide on the market. His process of electrical liberation of bromine from raw brine is reported to be the first successful application of electrolysis to the commercial production of a nonmetallic element. A later electrolytic product of his company is magnesium produced from a fused salt mixture high in anhydrous magnesium chloride.

Mr. Dow has an unusual interest in civic and philanthropic affairs and has devoted much time to public service. This spirit has been reflected throughout his organization, various members of which have from time to time been active in the government of Midland.

LAWRENCE ADDICKS



Lawrence Addicks

THE YEAR 1899 was an auspicious one in the life of Lawrence Addicks. It was then that he graduated from the Massachusetts Institute of Technology (completing both the mechanical and electrical engineering courses in four years), and shortly thereafter he was married. Being married, Mr. Addicks had to look for a job, and before long, he obtained one with the Santa Rita Copper Co. From 1900 to 1905, he was assistant to the superintendent of the Raritan Copper Works; during 1905 and 1906 he was chief engineer, DeLamar's Copper Refining Co.; from 1906 to 1914 he was superintendent of the U. S. Metals Refining Co.; and since 1914 Mr. Addicks has had a consulting practice.

Mr. Addicks is the author of "Copper Refining," a standard book on the subject, and since 1915 he has been a member of the U. S. Naval Consulting Board. Ever since 1900, when he began work in the Raritan Copper Works, Mr. Addicks had studied the fundamentals of electrolytic copper refining. He has been consulting engineer for the American Metal Co., for the Cerro de Pasco Copper Co., for a Belgian refinery that works metal from the Congo, and for a Spanish company that refines cement copper.

Alexander C. Humphreys

THE manufactured gas indusry of the United States owes more, perhaps, to Alexander Crombie Humphreys than to any other one man. With a background of some years in insurance and banking, he entered the gas industry as secretary and treasurer of the Bayonne & Greenville Gas Light Co., in 1872. In the following year he became superintendent of this company as well. This dual position was held until 1881, and at the same time Dr. Humphreys completed the engineering course at Stevens Institute of Technology.

Engineer, practical gas man and business administrator, Dr. Humphreys has devoted a large part of the past forty years to consulting work, during which time he has accomplished much of good for the gas industry, improving management and administration and fostering the use of sound scientific and engineering practice. He has also been for many years a leader in the work of engineering societies, particularly those interested in the gas industry.

A. C. HUMPHREYS

Dr. Humphreys was born in Scotland and, with a true Scot's love of the things of the mind, has found time in his busy professional life to devote to educational matters. Since 1902 he has been president of Stevens Institute of Technology, and, since 1907, president of the board of trustees of that institution.

Willis Haviland Carrier

"MANUFACTURED weather" is a reality in American manufacturing, and Willis Haviland Carrier has made it so. Under his guiding hand, sound engineering has been employed in the application of air conditioning to many industries with improved products and profits as the result.

Upon being graduated from Cornell in 1901 as a mechanical engineer, Mr. Carrier began his career as an apprentice with the Buffalo Forge Co., and within five years he had attained the position of chief engineer. He soon saw the possibilities that lay in the suitable conditioning of the atmosphere in industrial plants. By 1915, he had worked out the principles of this process and had organized the Carrier Engineering Corporation, to put these principles into effect. His success has been outstanding.

W. H. CARRIER

Photo by Gessford

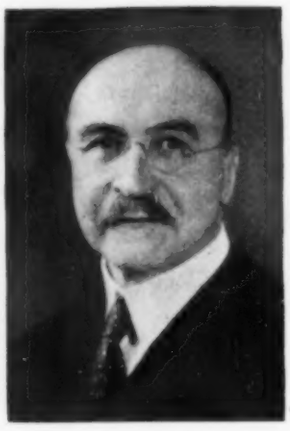
In addition to air conditioning, Mr. Carrier has devoted much time to the study of humidification, drying, air washing and refrigeration. His researches in these fields have been notably successful, and a large number of manufacturing plants are now benefiting from the commercial application of this work.

David Wesson

IN THE popular mind the name of David Wesson probably connotes salad oil, without knowledge of its cottonseed origin, but in the field of chemical engineering he is internationally known for his work on cottonseed as a raw material of chemical manufacture. In 1902, while he was at Savannah in charge of operation of the refineries of the Southern Cotton Oil Co., he started to develop the distillation of fatty acids from cottonseed soap stocks. In 1908 he principally designed and put in operation the Bayonne plant of the company, and in conjunction with the auditing department established a system of comparative reports that resulted in substantial economies of operation. Later his research work resulted in developing the process of hydrogenation used by his company for hardening oils.

During the war he was instrumental in putting his company into the manufacture of glycerine from cottonseed soap stock. He also took charge of the purchase of chemical supplies and located the cause of extensive losses in refining processes. One of the results of his research work was stabilizing and standardizing the manufacture of edible cooking fats; another was the development of the centrifugal machine for getting oil out of soap stocks.

DAVID WESSON
Alman & Co.



LEO. H. BAEKELAND
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EDWIN MORRISON
De Lue Studio

W. C. GEER

Leo. H. Baekeland

UNUSUAL capacity for turning his scientific investigations to commercial account has marked the life and work of Leo. H. Baekeland. He was born in the old Flemish city of Ghent and graduated from the university there. The award of a traveling scholarship enabled him to visit the United States where he shortly took a position as chemist for E. and H. T. Anthony, makers of photographic film and paper. Later he established the Nepera Chemical Co. for the manufacture of photographic papers and invented "Velox" which he subsequently sold to Eastman. Attracted by the growing electrochemical industry in this country, he went to Charlottenburg for study and returned to the United States to engage in electrochemical work. One of his early investigations involved the industrial development of the Townsend cell for chlorine and caustic soda.

Dr. Baekeland is probably best known for his researches on condensation products of phenol or phenolic bodies with formaldehyde or substances having similar functions, to form synthetic resins. Numerous experimenters had preceded Baekeland in this field of chemistry, but none brought their investigations to commercial importance and worth. His achievement was the result of a long investigation which ultimately led to the establishment of a new industry here and abroad.

Edwin Morrison

WHAT was originally expected to be a temporary engagement with the Franklin Sugar Refining Co. of Philadelphia in 1890, developed into a permanent position and directed the future connection of Edwin Morrison with the sugar industry. His first work involved process economies, especially with reference to heat conservation, but eventually he became assistant to the general manager with duties of mechanical and process control.

In 1903 he went to Colorado as chief engineer for the allied beet sugar factories in which the American Sugar Refining Co. was financially interested, and which were later grouped under the present ownership of the Great Western Sugar Co. In 1910 he was made general superintendent in charge of the company's factory operations and was elected a director in 1922. This company is the dominant factor in the beet sugar industry and a leader in the application of research and chemical engineering to beet sugar manufacture. Mr. Morrison's duties and responsibilities are reflected by the company's growth and present position. At its inception three factories were already built. Thereafter Mr. Morrison represented the company in the construction of eight factories built by contractors, and subsequently he had full charge of the construction of additional plants until, in 1927, nineteen factories were in operation and one under construction.

W. C. Geer

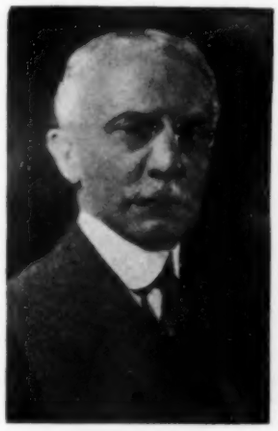
TWENTY years spent in research, development and executive work in the rubber industry have qualified W. C. Geer with exceptional knowledge of the chemistry of rubber and its manufacture into industrial products. He received his doctorate at Cornell in 1905 and taught chemistry there for two years. But in 1907 he became chief chemist for the B. F. Goodrich Company and successively occupied advanced positions until in 1920 he was elected vice-president. Aside from his contributions to the technology of rubber Mr. Geer has been active in gaining recognition for science and engineering in the rubber industry and in breaking down some of the conservatism and secrecy that surrounded the business and inhibited technical intercourse.

Improvements in practical compounding, the backbone of the rubber industry, and the development and use of antioxidants are the principal phases of rubber manufacture to which Mr. Geer has made technical contributions. Stimulus to research and the practical applications of the results of research were his special interest, and in this field he was conspicuously successful. During the war he assisted in the design and manufacture of gas masks, and prior to that period served as chairman of the Navy Department specifications committee setting up standard specifications for rubber goods. As a practical hobby he is interested in primary and secondary school education and while at Akron organized the Old Trail School and directed its policies.

John Townsend Baker

PROGRESS and efficiency are often measured by and dependent upon the precision of the instruments available to an industry. Analytical chemical reagents are such tools of chemical industry and no man has contributed more than J. T. Baker toward their improvement in quality and variety and dependability.

While still a student at Lafayette College where he earned his degree in 1882, Baker noted the inferior quality of imported reagents and with the friendly counsel and support of his chemistry professor, Dr. Edward Hart, he founded the industry in this country with which his name has been associated. About 1885 the two partners were joined by a third, George P. Adamson of the class of 1884, and the Baker and Adamson association continued until the business was absorbed by the General Chemical Company in 1902. But Baker was not to be separated for long from his chosen work, for in 1904 he set out independently and founded his own business, the J. T. Baker Chemical Co. The goal set for the new company was the ideal "C.P." and as a measure to that end the company was the first to adopt the frank policy of printing each analysis on the label of each product. Limits of impurities, like those in calculus that may be closed approached but never quite reached, have been constantly reduced in direct proportion to the great advances that have been made in quantitative analytical and production methods.



J. T. BAKER

E. L. OLIVER

G. W. THOMPSON

W. L. BADGER

Randall, Maedall Studios

Edwin Letts Oliver

IT WAS 20 years ago that continuous vacuum filtration, now so widely used in industrial processes, was first successfully applied to the treatment of cyanided ore slime by Edwin Letts Oliver. He was then metallurgist for the North Star Mines Co., Grass Valley, Calif., and developed the continuous vacuum filter as a means of solving one of the most troublesome problems then encountered in the treatment of ore by the cyanide process, namely, the handling of finely divided ore slime. This development places Mr. Oliver in that group of western ore metallurgists to whom modern chemical engineering is indebted for pioneer developments that have since been adapted to a wide range of industrial processes.

The first continuous vacuum filters were built by Mr. Oliver in 1907 and placed in operation in the cyanide mill mentioned above. In 1911 the machines were adapted to the dewatering of lampblack in the plant of the Los Angeles Gas Co. From that time their industrial applications widened. In 1914 they were used in chemical plants and in 1916 the method was introduced into beet sugar mills. The paper industry began to use continuous vacuum filtration in 1919, and the process was extended into sewage treatment in 1923 and into cane sugar manufacture in 1925. Thus this mechanism and method for handling ore slime has penetrated other industries in a manner characteristic of fundamental chemical engineering operations.

G. W. Thompson

THE PROSPEROUS HISTORY and present enviable position of the National Lead Co. is due in no small degree to the efforts of G. W. Thompson, chief chemist of the company since its organization in 1892. Its research laboratory has been organized entirely under his guidance and from this laboratory have come the technical processes of the company and its subsidiaries. Dr. Thompson's principal investigations have been on lead pigments; mixed paints; smelting and refining of metals; recovery of secondary metals; mixing and refining of alloys; linseed and other paint oils; titanium oxide pigment; and the smelting and refining of tin.

Besides his connection with the National Lead Co. itself, Dr. Thompson is a director of the Williams-Harvey Corporation; Williams-Harvey Co., Ltd., of Liverpool, England; Titanium Pigment Co.; United Lead Co.; and the Metallurgical and Chemical Corporation. During the War a smelting plant was established under his direction for producing pig tin from South American ore. He was associated with the development of the new white pigment produced from titanium oxide, namely, Titanox, and he has developed a new flatting oil for use with white lead for interior painting and also a red lead of extremely high oxide content which is ground in linseed oil and marketed as a paste. During 1917 and 1918 Dr. Thompson was president of the American Institute of Chemical Engineers.

W. L. Badger

THE EARLY LIFE of Prof. W. L. Badger centers in Minneapolis, Minn. There he was born, brought up and educated; furthermore his first job was assistant in chemistry under Dr. Francis C. Frary of the University of Minnesota. After spending a campaign with the Great Western Sugar Co. as chemist in their Brush, Colo., laboratory, Prof. Badger returned to the University of Minnesota as instructor in general chemistry, and remained there during the year 1910. He next went to the Bureau of Standards as laboratory assistant in chemistry, remaining until 1912, when he went to the University of Michigan as instructor in chemical engineering, a connection he has retained, with promotions, to the present day. Prof. Badger's early work at Michigan was on gas and fuel analysis, but later he developed engineering courses, particularly in heat transfer and evaporation and other unit processes of chemical engineering.

In 1916 Prof. Badger become associated with the Swenson Evaporator Co., the development work of which he has supervised since that time. A co-operative agreement was effected between the Swenson Evaporator Co. and the University of Michigan whereby fundamental research is carcied out in an evaporator experiment station to which students have access. Prof. Badger has been granted patents on the evaporation of substances having an inverted solubility curve and on improvements on the Yaryan-type evaporator.

Charles E. Munroe

TO REVIEW even the outstanding achievements which Dr. Charles E. Munroe has contributed to chemical industry during the past 56 years, is a task beyond the perspective of a single individual. There is no phase of activity in the development of chemistry in America that has not felt the influence of this beloved pioneer in chemical science and its industrial application. But Dr. Munroe is best known in our industries as the "Dean of Explosives Chemists," a title merited by a half century of scientific work on explosives for the United States Government and as a consultant for other governments and for explosives manufacturers.

Following graduation from Harvard in 1871, he served for three years as research assistant to Wolcott Gibbs. Then followed twelve years as professor of chemistry at the U. S. Naval Academy until 1886 when he was called to work on chemical activities at the Torpedo Station and War College. It

CHARLES E. MUNROE
© *Harris & Ewing*

was here that he invented indurite, the first smokeless powder to be used in the large guns of the U. S. Navy. While here he also discovered the principle of detonation known as the "Munroe effect" which has proved its usefulness in subsequent military developments. Dr. Munroe was head professor of chemistry at George Washington University and dean of its graduate school from 1892 until his honorable retirement in 1917. He continues unusually active in other scientific matters, however, particularly as chief explosives chemist for the U. S. Bureau of Mines, and as chairman, since 1918, of the committee on explosives investigations of the National Research Council.

A past president and one of the surviving founders of the American Chemical Society, an honorary fellow in the American Institute of Chemists, and an officer of the American Association for Advancement of Science—Dr. Munroe has contributed his share to the progress of the scientific societies as well as to the industries with which he has been associated.

MAXIMILIAN TOCH

Maximilian Toch

FORTY-THREE YEARS ago Maximilian Toch was graduated from New York University with the degree of Bachelor of Science, and that same year—1884—he entered the paint business, a field in which he is everywhere recognized as an authority and which has received immense benefit from his researches. Not only has he introduced in the paint industry some strikingly original methods, but he has by his writings, lectures and personal research work laid down the basis for more rigid paint specifications. Whatever Dr. Toch has published on technical paints has always stirred up interest among engineers, and he early set a new and commendable example to his fellow manufacturers by being frank, outspoken and undisposed to keep trade secrets out of the literature.

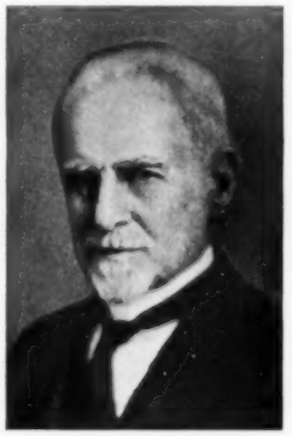
Dr. Toch is now a member of the firm Toch Brothers, professor of chemistry of painting, National Academy of Design; honorary professor of industrial chemistry, Pekin Technical College; and a member of many scientific societies. He is the author of "Chemistry and Technology of Paints" and "Materials for Permanent Painting and How to Paint Permanent Pictures." Dr. Toch has served as chairman of the New York Section, Society of Chemical Industry and as president of the Chemists Club, New York.

JOHN E. TEEPLE

John E. Teeple

DISTINGUISHED primarily for his achievement in developing an American potash industry, John E. Teeple has had a long and successful career as a consulting chemist and chemical engineer. For his work in recovering potash and borax from Searles Lake brine he was awarded the Perkin Medal in 1927. He was educated at Valparaiso College and Cornell University. Except for teaching experience at Cornell from 1899 to 1904, and later (1917) as a special lecturer in chemical engineering at Columbia University, Dr. Teeple has been engaged in consulting work. His clients have included many of the principal chemical manufacturers of the United States and his investigations have taken him into a wide and varied field.

In addition to his technical knowledge Mr. Teeple possesses business ability which scientists are supposed to lack, but which is essential in gaining the confidence of financial men and making



GEORGE A. PROCHAZKA

chemical engineering ventures profitable. This same quality is brought to bear on the financial management of the American Chemical Society, of which he is national treasurer. He is prominent in the affairs of the Chemists' Club, New York, and served as president in 1921, 1922 and 1923.

George A. Prochazka

GEORGE A. PROCHAZKA had the advantage, rare in the post Civil War period, of an excellent technical training. He went to Germany in 1868 to study in the Konigliche Realgymnasium in Wiesbaden. After this he studied in the chemical laboratories of Fresenius and in the University of Heidelberg, from which he graduated in 1874, with the degree Ph.D. summa cum laude. Not content with this training, Dr. Prochazka continued his studies at Bonn, under Kekule and Wallach; this was followed by courses at Aix la Chapelle in chemical engineering.

After serving on the staff of the Stevens Institute of Technology, Dr.

Prochazka entered the dye industry. From 1887 to 1897, he was connected with Heller & Merz, and for many years he was general manager of the plant. In 1898 he incorporated the Central Dyestuff & Chemical Co., of which he was president until he sold his interest in 1924.

Dr. Prochazka has been active in scientific society affairs for many years; he is a charter member of the Chemists Club, and in 1908 he served on the committee that created the Perkin Medal Award.

L. F. Hawley

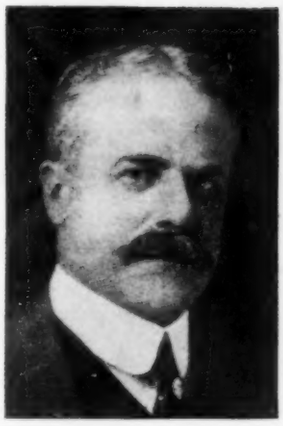
EVER SINCE he entered the Forest Service in 1907, immediately after taking his doctorate in Cornell University, Dr. Hawley has been informally identified with the wood distillation industry in an advisory and research capacity. Not all chemical engineers are proud of their first published articles. Dr. Hawley, however, has a right to be, as his early bulletins on the

L. F. HAWLEY

analysis and refining of wood turpentines, the steam distillation of resinous wood and the determination of yields from hardwoods are still standard references.

Shortly after the Forest Products Laboratory was established in 1910, Dr. Hawley was placed in charge of all the chemical research on wood except that on pulp and paper, and he has continued with that work with the exception of a period of about three years spent mostly with Arthur D. Little, Inc. Besides his own specialty of wood distillation, Dr. Hawley has had general supervision of research on wood hydrolysis, the chemical composition of wood, characteristics of wood preservatives and the colloid chemistry of wood. During the War, his efforts were concentrated on the problems of activated charcoal and calcium acetate.

Dr. Hawley has contributed generously to the American literature of wood chemistry and technology, and more recently he has become still better known through his books "The Chemistry of Wood" and on "Wood Distillation."



WILLIAM M. BURTON

William M. Burton

A TRUE PIONEER in the application of scientific research and technical development in the oil industry, Dr. William M. Burton has long held a position of leadership among the petroleum technologists. In 1889 when he entered the employ of the Standard Oil company at its Cleveland, Ohio, refinery he was one of the first graduate American chemists in the industry and when transferred a year later to the Whiting, Indiana, plant, he set about building the technical organization that has since brought much credit both to the petroleum industry and to the chemical profession.

Dr. Burton was general superintendent of the Whiting refinery in 1895, a member of the board of directors in 1911, vice-president in 1915 and in 1918 became president of the Standard Oil Company of Indiana. This position he held for nine years during a period of tremendous growth and expansion in his company's business. Recently retiring from the presidency Dr. Burton continues as a director of the company.

During his active connection with manufacturing operations at Whiting, Dr. Burton gave much of time and thought to scientific research. This led in 1913 to the commercial development under his direction of the Burton process—the forerunner of the tremendous progress that has since been made in the cracking of distillates.

HUGH K. MOORE

Hugh K. Moore

CHEMICAL ENGINEERS familiar with the pulp and paper industry agree that the Brown Co. has long been a leader in the application of scientific control and research to this giant industry. The man responsible for this pioneer effort is Dr. Hugh K. Moore, technical director of the Brown Co. In 1896, after attending the Massachusetts Institute of Technology, young Moore worked for the Electron Chemical Co. of Rumford Falls, Me. In 1897, however, he left in order to develop his own process for the electrolysis of salt, being chemical engineer for the Moore Process and Moore Electrolytic Co. Out of this work came the well known Allen-Moore cell.

Following the development of the electrolytic cell, Dr. Moore became chief chemist and chemical engineer for the Burgess Sulphite Fibre Co., and later he was appointed to the same post with the Brown Co., a combine of several mills, of which the Burgess Sul-

J. V. N. DORR

phite Fibre Co. was one. In 1925 Dr. Moore was awarded the Perkin Medal, and during 1926 he was president of the American Institute of Chemical Engineers.

John V. N. Dorr

IT IS AN interesting historical fact that some of the best known and most widely used chemical engineering operations and equipment had their inception and early application in perfecing the cyanide process for the recovery of gold and silver from their ores. Striking evidence is to be found in the career of J. V. N. Dorr whose contributions to the art of classifying, settling and agitating suspensions of finely divided solids in liquids have found wide adoption.

In 1902 he found himself operating a cyanide mill in the Black Hills, South Dakota. Here he was confronted with the problem of separating ore, crushed in cyanide solution, into "sand" and "slime," the better to effect recovery of the precious metals. The difficulty was overcome by his invention in 1904

of the mechanical classifier which bears his name. This device produced a readily leachable sand product and a thin slime which required thickening. The intermittent process of thickening by sedimentation and decantation which was in use at that time proved unsatisfactory, and after considerable experimentation Mr. Dorr invented his continuous thickener in 1906. A natural sequence to the success of the thickener was the development of the continuous counter-current system of decantation which later found wide application. In 1910 Mr. Dorr invented his agitator to meet a specific need in connection with the counter-current process. He was the first to apply successfully the process of vacuum filtration invented by George Moore.

Charles H. MacDowell

FORTY YEARS association with Armour & Company furnishes the background of experience from which Charles H. MacDowell has made notable contributions to the technology of the fertilizer and related chemical industries. It was his privilege to start the fertilizer department of his company in 1894. Since 1911 he has been president and director of the Armour Fertilizer Works. He has served as director and since 1923 as vice-president of the parent company.

Mr. MacDowell's technical achievements have been numerous. He first developed the manufacture of blood albumen and introduced the use of direct heat dryers, revolving drum mixers and many other innovations in fertilizer manufacturing practice. Research and development work during the War resulted in the first commercially producing American potash plant, using for its raw material the mineral alunite. A process for recovering potash from leucite was also developed. Mr. MacDowell has had a part in the development of several noteworthy improvements in the chamber process of sulphuric acid manufacture and in the use of vanadium-alumina as a substitute for platinum in contact acid plants.

Edward Weston

AMONG the pioneers in the electrochemical industry Edward Weston holds a conspicuous position on account of his inventive activity and creative contributions.

Early in his career he was employed in the manufacture of photographic chemicals and there learned the necessity of observing closely the details of chemical and physical phenomena. It is likely that habits of investigation and inquiry, careful experimentation and determination of facts were formed at that time and influenced all his later work. In all the problems he attacked he substituted precise knowledge for empiricism and scientific method for rule-of-thumb. Thus he successively introduced order and method into electroplating, electrolytic refining, dynamo construction, electric illumination and methods of electrical measurement. In all of these fields he did pioneer work, disregarding the practices of the time and upsetting some established notions. Not the least of his inventions was the Weston standard cell which was internationally adopted as a standard for electromotive force.

In his early years, between 1873 and 1886 Mr. Weston took out over 300 patents, and like many inventors was involved in expensive patent litigation to protect his products against infringement. His leadership, however, remains unquestioned and today he is revered no less for his modest and generous nature than for his pioneer contributions to electrochemical industry.

Charles L. Reese

THE PRESENT YEAR marks the silver anniversary of Dr. Charles L. Reese's connection with the duPont company. In 1902 he took charge of a small chemical research laboratory and from this beginning his position steadily grew in influence and responsibility. Immediately before and during the War, Dr. Reese as chemical director for the duPont company had charge of enormous chemical engineering developments. It was in this position that he developed the men, processes, plants and technical organizations that helped to make possible the munitions program of the United States and the Allies. In 1924 when Dr. Reese retired from active direction of the chemical activities of his company, he was elected a member of the board of directors and made chemical advisor and consultant to E. I. duPont de Nemours & Co., Inc.

Dr. Reese's training in pure science —he was a student of Professor Mallett at Virginia, took his doctorate at Heidelberg under Victor Meyer and for sixteen years was a teacher of chemistry—stands in striking contrast to his industrial success in the practical application of science.

George M. Norman

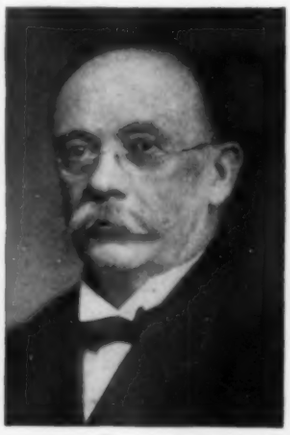
TWENTY-TWO years experience, spanning the most eventful period in the history of the explosives industry, has furnished the background for the many chemical engineering developments that have been directed by George M. Norman. His connection with the industry dates from 1905 when he began work at the Repauno plant of the du Pont company, where he remained until April, 1913. Then he joined the recently organized Hercules Powder Company and assumed charge of its chemical operations. It was necessary for Mr. Norman to build up a real technical organization in order to handle the many problems arising in the manufacture of military explosives for the Allies.

It was the experience gained in these trying years that made it possible in 1917 and 1918 for Mr. Norman to organize and direct for our own Government the tremendous forces of technical men who carried on munitions manufacture in Hercules plants.

The present technical department, of which Mr. Norman is the director, employs 150 men and operates an experimental station at Kenvil, N. J., and a semi-plant scale development at Brunswick, Ga. From this department have come many significant developments.

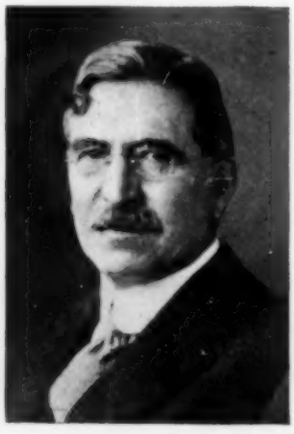
CHARLES H. MAC DOWELL

EDWARD WESTON



Almon & Co.

CHARLES L. REESE



Wm. Shewell Ellis

GEORGE M. NORMAN

Wm. Shewell Ellis

Rubber Industry Has Notable Record of Progress

By William C. Geer
New Rochelle, N. Y.

FROM 1902 to 1927 the rubber industry literally has altered its entire chemical engineering practice. Such machines as the mixing mill, the calender, the platen press, the tubing machine and the open steam vulcanizer are essentially the same. But rubber goods do not consist of presses nor calenders; they are made of cotton fabric and rubber mixtures. It is no idle boast to say that the quality of rubber goods has doubled since 1902. Pneumatic tires in that year might run, if circumstances were favorable, a matter of three or four thousand miles. In this year of Grace, they give the consumer an average of twelve and more thousand miles. The conveyor belt twenty-five years ago was much of a problem; today it carries upon its surface many thousands of tons of ore with but little wear. Fire hose years ago was an article to worry about, for the fear was constantly expressed lest it age badly and thus in time of prime need give way because of a decayed lining. Many were the millions lost due to burst and leaking hose. Nowadays fire hose is as stable as the fire engine and ready to serve when the gong clangs.

These are but a few of the articles made by the rubber industry which have been improved through the application of new knowledge of the chemistry of rubber or because of chemical engineering in the rubber industry. To be precise, the chemist, be he research chemist or chemical engineer, has made great and startling changes during this past quarter century. Let us consider a few only of the men and the outstanding achievements which have been woven into this business.

The mixing room is the heart of the rubber factory, for here it is that the numerous substances are mixed together with rubber in order to form mixtures of desired properties and of uniform quality. Some new types of mixing machines have been invented. For many years, even from the time of John Hancock, the two-roll rubber mixer has been standard. These mixers are made on the principle of two parallel rollers, the rubber being squeezed between them. Internal mixers, however, developed by Banbury and by Farrel are now used, the principle of which is one or two specially designed rollers within a strong steel shell. Temperature control is maintained by cold water in a jacket of the shell and in a cavity in the mixing blades. Where the weight of composition which could be mixed on the old mixers was at the most 250 to 300 lb., now it becomes possible to mix 750 to 850 lb. of composition in approximately the same length of time. This mixing machine is safer for the workmen, the material seems to blend better and the cost per pound of stock is less. Certain compositions cannot be mixed successfully but it is probable that the future of this machine is secure. The manufacture of crude rubber for our uses has not changed in any large way, yet we must note certain achievements. In the making of rubber from latex of the trees of the Far East, Ernest Hopkinson has developed a process which has succeeded in the production of a grade of crude rubber not previously put upon the market and of a quality higher than that produced by the customary means. Hopkinson sprays liquid latex into a hot neutral atmosphere quickly drying it to a solid grade of rubber which contains all the latex substances. It is known as L.S. rubber.

Modern science has confirmed Hopkinson's judgment for the work of the research chemist shows that the less rubber is masticated or heated the better it is. The thing therefore which the spray drying of rubber seems to have done is to maintain the crude rubber in as high a degree of quality as nature created it in the tree. Hopkinson has also taken the lead in the use of latex in place of benzene cements, a field in which the future may hold some worthy advances.

When we think of crude rubber our minds usually picture the Far East and a milky latex. In this country, however, a method of gathering rubber has recently come forth, the roots of which go back twenty years, and which is destined to play a mighty part in the future. It is the collection of rubber taken from a shrub in Mexico and known as guayule rubber. The fact that this shrub contained a rubber substance had long been known but it remained for Wm. A. Lawrence to find a practical means for extracting it. The rubber in this shrub is not contained in the form of latex but is in solid form throughout the mass of wood. Botanists can tell us why nature secretes rubber in this way but the difficulty of extracting it was manifest. Lawrence solved the problem in good chemical engineering fashion for he developed machines for breaking down the wood and grinding it under water in such a way that the woody material was water-logged and separated. The rubber on the other hand, rolled up into little balls, which were collected, further washed on washing mills and dried. This is a hasty sketch of Lawrence's famous method.

Many were the problems involved, and much of the original practical development in improving the quality of guayule was due to the work of Dr. David Spence, not only during the time he was the head of the research laboratories of the Diamond Rubber Company but also in these recent years during his association with the

ERNEST HOPKINSON

To Mr. Hopkinson, vice-president in charge of the patent and development departments of the United States Rubber Co., belongs a large share of the credit for three outstanding processes, sprayed rubber, web cord and the flat band method of tire manufacture. He began his career with the United States Rubber Co. in 1897 as patent counsel.

Photo by John N. Kelly

DAVID SPENCE

Although born in Scotland and educated in the Royal Technical College, the University of Jena and the University of Liverpool, Dr. Spence has for a score of years been identified with the American rubber industry: the Diamond Rubber Co., The B. F. Goodrich Co., the Norwalk Tire & Rubber Co., and the Intercontinental Rubber Co., of which he is vice-president.

S. E. SHEPPARD

S. E. Sheppard came to the newly founded Eastman Kodak Company Research Laboratory in 1913 from England, his native country. Although well known for his investigations and writings on the theory of photographic processes, he is also responsible for the development of processes for the electrodeposition of rubber with L. W. Eberlin and C. Beal.

HARRY L. FISHER

Dr. Fisher's connection with the rubber industry dates from 1912, when he became research chemist for the B. F. Goodrich Co. He patented processes which resulted in Vulcalock, the well known bond between rubber and metal. In 1920 he wrote "Laboratory Manual of Organic Chemistry." Dr. Fisher is now research chemist for the United States Rubber Co.

Continental Rubber Co. That company is deserving of outstanding credit because of its foresight and efforts in the cultivation of the guayule shrub in California and the extraction of the rubber from it by methods greatly improved over the original Lawrence scheme.

From crude to reclaimed rubber is a shorter step today than formerly, for prior to 1902 old vulcanized rubber used and thrown away was changed into "shoddy," as they said, by grinding it and destroying the fabric by treatment with acid and heating. This yielded a somewhat plastic mass which could be mixed into fresh rubber but which had the effect of weakening the mixture and which decayed or perished rapidly on standing. Many tons of it were used, to be sure, but there was much that it could not do. It was in 1899 that a brilliant young chemist, working in a rubber factory in Boston, developed an entirely new process, to which his name has been given, and which has stood the test of law and service down to today. This so-called alkali process was discovered and patented by Arthur H. Marks. He found out, by laboratory experiment and practical chemical engineering, that on heating ground vulcanized rubber in a weak solution of sodium hydroxide under pressure, not only would the cotton fabric be destroyed but the rubber would be plasticized and brought it into a condition for remixing into crude rubber. And the strength and other physical properties of this "reclaimed" rubber were superior to any previously known. The Marks process came into very rapid use and the products made by it have been used in practically all grades of rubber goods and to advantage. Indeed, in 1926, the reclaimed rubber consumption reached a total of approximately 35 per cent of that of crude rubber. The Marks process still dominates.

Mr. Marks was not only a chemist of imagination, foresight and resourcefulness but he was a factory manager of rare attainments. It is safe to say that every man who ever worked under his genial direction came to love him, to recognize his ability and today honors him for the stimulus of his keen intellect and kindly sympathy.

Another major achivement has been the use of organic chemicals in rubber mixtures, and the reduction of rubber practice to a scientific basis. In the early days of rubber manufacture the only substances mixed with rubber and sulphur were common paint pigments such as white lead, zinc oxide, whiting, etc. These substances were used for various purposes but among them were several which permitted the time of vulcanization to be shortened. To vulcanize a soft rubber mixture composed of nothing but rubber and sulphur required from three to five hours' heating. Certain inorganic compositions permitted the time to be greatly reduced but the quality was not particularly improved. It remained for the year 1906 to show the first practical application of the organic compounds now called accelerators which would shorten the time required for vulcanization.

George Oenslager who worked in the laboratories of the Diamond Rubber Company, in Akron, first tested the idea of the use of aniline oil for this express purpose in rubber mixtures. The good results then led him to try heavy organic compositions which contained nitrogen. Without going further into the history of Mr. Oenslager's work, which has been written in some detail in another place, and with no attempt to appraise the wealth of articles which have been written and the large number of patents which have been granted descriptive of different organic accelerators and how they act, we must content ourselves with almost a categorical statement that the use of these organic substances in rubber mixtures has become so widespread that there are very few rubber compositions which do not contain one of them.

They have permitted the time of vulcanization to be

reduced, and the quality of the resulting article to be raised until now the average time of vulcanization of rubber goods is about one-third what it was in 1902. Because of this reduction in time of turnover of molds and vulcanizers the investment in machinery necessary for vulcanization of the present volume of rubber goods is much less than it would be had no organic accelerators been discovered. I assume that this discovery alone has been the means of saving to investors clearly $200,000,000; and due to accelerators alone the consumer of rubber goods gains an improved quality worth over $200,000,000 per year.

THE men who have made these accelerators possible have been many; the notable ones are Oenslager, Marks and Spence, and the latter can take pride in the fact that one of his accelerators has continued an uninterrupted career in industry down to today. Other names are written large in the book of achievement in this field: Bedford, Scott, Sebrell, Gibbons, Cadwell, North and many others.

The use of the organic accelerators has brought problems into the industry, not the least of which was how to control the temperature when the time is so short. Someone began and several have improved automatic apparatus by which the temperature during vulcanization is accurately controlled, and the practice of automatic temperature control has been almost universally adopted. In the great tire factories the steam heat is turned on and off the presses in accordance with a prearranged schedule by these automatic instruments, because of which the quality of rubber products has been brought to a high degree of uniformity.

Rubber, however, has always shown a tendency to decay because of oxidation. This difficulty led chemists for many years to study whether substances could be found which, mixed with rubber, would prevent or at least, delay this decomposition. Some few such antioxidants are in use and there is no longer any excuse for the "perishing" of rubber goods during storage and the life is lengthened when in use.

For the chemical industries some value and service is on the way because of the work of Fisher in the Goodrich laboratories. He has transformed the rubber molecule into substances which approximate gutta percha in physical properties, one characteristic of which new substances is the fact that they adhere to metals. Others have done much in the chemical engineering developments of these substances for protective coatings in the chemical industry, and although this field is new the influence of it will extend on into the future.

One of the new schemes which developed in two research laboratories simultaneously, and which is in a state of chemical engineering development at the present time, is the electrodeposition of rubber from latex, worked out by Sheppard of Rochester and Klein of Budapest. The so-called anode rubber takes its name and origin from the fact that the particles of rubber in latex carry a negative charge and under the influence of electric stress can be deposited on the anode. The peculiarity of this process and the one which is the reason why its development progresses successfully is the fact that this deposit of rubber, thus formed unvulcanized and together with strengthening pigments, has had no mechanical work done upon it and has not been subjected to heat. Thus, the solid sheets of rubber in nearly any desired shape contain the rubber substance in the best possible condition and therefore of the highest possible quality. The anode rubber process is in its infancy, but it is an outstanding development with a marvelous future.

These several inventions and discoveries alone have not made those changes in value by which the consumers of rubber goods have profited during these later years. Crude rubber is better, although of many grades, accelerators are so numerous that a wealth of choice is possible, reinforcing pigments cannot simply be used in a hit or miss manner, and to gain value from reclaimed rubber and anti-oxidants the rubber chemist must needs possess skill and experience before the rubber goods in which they are incorporated can stand the test of service.

The climax of this story centers in the laboratories and rooms of the rubber compounder or the rubber chemist. He is the master baker who writes the recipes for hose covers and tire treads. He it is who, with thousands of substances at his command, with a knowledge of the chemical properties of each and with a keen understanding of the service to which the articles are to be put, can so combine the several essential ones that after vulcanization the particular mixture of "compound" may show the necessary service value. His has been a study in chemical engineering design.

He has changed the old conception that anything used in a rubber mixture, except rubber and sulphur, was a "filler," useless to the consumer but profitable to the manufacturer. Zinc oxide and carbon black are known today to add definite reinforcing properties to mixtures. A tire tread without them would wear out rapidly. The particle size, shape and surface tension relations toward rubber have been found to be determining factors in the utility of such dry powders.

These men have discovered and applied research knowledge with the result that the service quality of all grades of rubber goods have essentially doubled during the past twenty-five years. No one chemist is responsible for this marvelous change in quality. It has been a change brought about by the work of many, and most of them are still young. Such men as Bierer, Boggs, Breyer, Cranor, Dinsmore, Evans, Miller, Meyer, Oenslager, Schade, Sheppard, Spear, Spence, Warner, Weber and many others have been responsible for these striking improvements.

LET me close this brief review of men and events in the rubber industry during the past twenty-five years by mention of the mainstay of our great industry. A significant development during these years is the growth of the Rubber Division of the American Chemical Society and the Akron Section of the American Chemical Society. In these institutions men connected with the chemical and chemical engineering departments of the rubber factories talk over affairs and enjoy the associations which come through such contacts. It is indicative of a changed vision on the part of the executives of the corporations that they have seen fit to permit their chemical assistants to join in these enterprises, and it is proof that the rubber industry has graduated from the school of secrecy and suspicion into the world of harmony and co-operation.

Developments in Glass Technology During Recent Years

By George W. Morey
Geophysical Laboratory
Washington, D. C.

TWENTY - FIVE years have seen the glass industry completely revolutionized. One of the oldest of industries, it had existed for centuries under the spell of secret formulas, and entirely a small-scale, many-unit skilled craftsman's constant personal triumph over miserably poor and inefficient equipment. This has been largely overcome, and it is now an industry in which skilled engineering, based on exact scientific knowledge has largely replaced the personal element.

The glass industry of today is a mechanical one, mechanical to an extent that would have been thought impossible twenty-five years ago. Then practically all ware was worked in small units, usually by hand. Hollow ware was blown; pressed ware was hand fed; plate was rolled pot by pot; and continuous annealing was an experiment.

Many inventors have had a part in revolutionizing the industry and fortunes have been made and lost in promoting glass working machinery. To correctly allocate the credit for each step in the process would not be possible, but the name of Michael J. Owens, at his death a vice-president of the Libby Glass Co., stands out for the extraordinary success of several inventions with which he has been associated, especially the Owens bottle machine, and its adaptation to electric light bulbs, the Westlake machine.

The Owens bottle machine, introduced in 1903, was the first completely automatic glass blowing machine, and today it occupies a dominant role in large-scale production. When production records of an average of 10,080 marketable bottles per hour on a 10-arm machine are considered, it is easy to see why the Owens machine has revolutionized glass bottle manufacture. There are today several other machines said to be as serviceable and efficient as the Owens.

The Owens machine is primarily intended for and adapted to large-scale production of a particular article, but a large proportion of blown glassware can still be more economically manufactured on the semi-automatic machines. These machines were in extensive use twenty-five years ago, and since then they have been successfully applied to still more types of glassware, including tumblers and thermos bottles. A semi-automatic machine requires the services of a feeder to gather the glass and an important development has been the invention of successful automatic feeders for use with them.

Twenty-five years ago electric light bulbs were hand blown by skilled workmen and no one thought of making such thin-walled fragile objects in any other way. Well over a million bulbs are now produced for every day in the year, and practically all of them are machine blown. Two types of machines are in extensive use, the Empire and the Westlake. The Empire machine is semi-automatic, the glass being gathered by hand on a blowing iron or fed in by an independent automatic mechanism. The subsequent operations are entirely mechanical, and are a close imitation of the motions made by a glass blower. The Westlake bulb machine, designed by August Kadow, is an adaptation of the Owens bottle machine--designed for thick ware and leaving a mold mark—to thin ware, free from a mold mark; and it appears today to be the culmination of efforts to apply mechanical methods to glass blowing. It gathers by suction directly from the pot or tank, blows the bulb, and delivers it to the annealer, the operation being entirely automatic. More than 60,000 bulbs of household size per 24-hour day have been produced on a single 24-mold machine.

The Brooks feeder, patented in 1901, and developed to higher perfection since was the first successful feeding machine. It is still in extensive use. It relies on the flow of glass through an orifice, and, while it has the advantage of simplicity, does not make possible as close control of size and shape of the glass gob furnished as is accomplished by more recent inventions, such as the Hartford-Fairmont feeder. In this latter a paddle dips into the molten glass and splashes successive waves of glass over a lip into an orifice, from which the gobs are extracted by a plunger. By suitable adjustment it is possible to secure gobs of widely differing shapes, according to the article which is to be made.

The successful application of mechanical methods to window and plate glass is another accomplishment of the period. The first successful machine for blowing window glass was invented by J. H. Lubbers, in 1903. A hot "bait" is dipped into the molten glass, and withdrawn at the proper rate to form a cylinder of uniform thickness and diameter. To prevent the cylinder walls from drawing in as the cylinder is raised, air under pressure is admitted, and by this method cylinders 40 ft. in length are successfully produced. The cylinder so drawn up must be split and flattened, in a separate furnace, and finally slowly annealed.

Many inventors have attempted the direct production of flat sheet glass. The most successful sheet process is that devised by I. W. Colburn, and developed by the Libby Glass Co. By the Colburn process either single or double strength flat glass can be produced, or even

quarter-inch sheets which compete with rolled and polished plate. In drawing sheet glass the difficult thing is to keep the sheet glass of constant width; in the Colburn process water-cooled rollers grip the edge of the plate as it is drawn, and so overcome the tendency for the sheet to become narrower. One-third of the sheet glass produced in the United States is now made by the Colburn process.

Plate glass has had two important technologic developments in the past twenty-five years, the development of continuous lehrs for annealing, and the continuous rolling of the plate itself.

Another branch of the glass industry in which hand processes have been supplanted by machines is the drawing of tubing, of which large quantities are required for the electric lamp industry, for miscellaneous blown ware, and for clinical and physical purposes. The machine used for this purpose, called the Danner tube-drawing machine, is another of the successes of the Libby-Owens Co.

The mechanical improvements in glass technology are the most spectacular, but progress in the chemical side of glass technology has been noteworthy. Particularly important are the achievements of the chemists of the Corning Glass Works, headed by E. C. Sullivan, who have developed Pyrex; many colored glasses used in railway and highway signal work, of which the solenium ruby is an example; the lead-free bulb glass used for machine production of electric light bulbs; and, more recently, a silica-free glass highly transparent to ultra-violet light.

The development of Pyrex glass is a conspicuous example of the successful application of scientific method. To withstand heat and cold in a brakeman's lantern on a stormy winter night a glass with a low coefficient of expansion was needed. For that purpose it was desirable to have present as small a proportion of the alkali and alkaline earth oxides as possible. Sullivan and Taylor initiated an experimental study of the coefficient of expansion of glass, in its relation to composition, which resulted in the development of Pyrex. Pyrex expands only one-third as much as ordinary glass when heated and so is eminently suitable for the purpose for which it was intended, and can even be used in place of metal plates or porcelain for baking purposes. While not primarily developed for chemical ware, its conspicuous advantages in chemical composition make it superior to all of its predecessors, even in its resistance to chemicals, and it is now the standard chemical ware the world over.

When the Westlake machine was first introduced a soft lead glass was used, because it alone possessed the essential temperature-viscosity relationship. It had other drawbacks, however, and it is now largely replaced by a lead-free glass containing notable amounts of magnesia and alumina. The selenium ruby glass has so completely replaced the copper ruby that even samples of the latter are hard to obtain. Recently, Hood, of the Corning company, has described a glass almost as transparent to ultra-violet light as the expensive fused quartz glass, and which can be produced in quantity.

Another important advance in glass chemistry has been the special types, such as Crooks glass, used for spectacle lenses, and welders' glasses. Also notable is the heat-intercepting structural glass developed by L. T. Sherwood, which absorbs 78 per cent of the heat rays.

Another large class of special glasses are those grouped under the term optical glass. Some of the optical glasses are almost identical in composition with commercial glasses in wide use, others differ greatly, but all are distinguished by a physical perfection which is only attained by careful adherence to rigidly defined conditions of manufacture. In addition to physical perfection, such as freedom from stones, bubbles, striæ, and strain, optical glass must have definite and reproducible optical properties, only to be attained by careful control of composition. The optical glass used in this country prior to the war was all imported from Europe and when that source of supply was cut off existing stocks of optical glass were quickly exhausted. When we entered the war not only was there practically no glass of optical quality available, but there was no optical glass industry. No one knew the processes of manufacture through which to produce the enormous quantities required by the army and navy. The industry always had been a highly secret one, and even under the stress of the war, when other information was freely exchanged, our allies

E. C. SULLIVAN

While directing the chemical works of the Corning Glass Works, of which he is vice-president, Mr. Sullivan has had an active part in the development of special glasses such as Pyrex.

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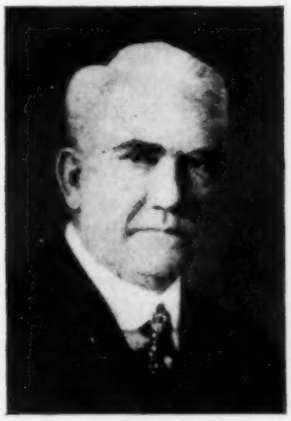


MICHAEL J. OWENS

The late Mr. Owens, a vice-president of the Libby Glass Co., was the inventor of the Owens bottle machine, a device which caused a complete revision of glass manufacturing methods.

J. W. CRUIKSHANK

As a consulting engineer, Mr. Cruikshank has specialized for years in the engineering work of the plate and sheet glass industries, making his headquarters in Pittsburgh.

E. WARD TILLOTSON

As assistant director of the Mellon Institute, Dr. Tillotson has been actively connected with the researches on glass that have been carried out there for a number of years.

could offer us only the assistance of their experience. There was, however, in this country an organization devoted to the study of silicate chemistry, though for purely scientific purposes; and, as glass technology is essentially a branch of silicate chemistry, to the Geophysical Laboratory was assigned the task of making optical glass. After a few months of experimental effort they succeeded, and, of the 675,000 lb. of optical glass manufactured during the war, over 95 per cent was made under the direction of this laboratory. About 2.8 per cent was produced at the Bureau of Standards.

It is unfortunate that the optical glass industry in this country failed to receive support and is now a thing of the past. But what has been done before can be done again, if there is time; and the experience gained in the manufacture of optical glass is not entirely lost.

Progress has also been made in another field, the field of pure research on glass and its composition, which will in the future play an important part in glass technology. There has been great activity in England, which has given us much information on the properties of glass. Peddle published an important series of papers on the relation between composition and properties of the optical glasses, which is the most complete study yet published. Turner and his co-workers in the Department of Glass Technology in Sheffield, have done much to increase our knowledge of the properties of glass, not only of optical properties, but also the working properties of glass, its chemical stability, strength, and annealing. Great interest is being shown in the viscosity of glass, and several workers have studied the problem. The viscosity of glass is of paramount importance to the technologist, because practically every operation in glass manufacture, from melting and firing to annealing, is dependent for its success on the glass having the proper viscosity at the proper temperature. The problem is one of great experimental and theoretical difficulty, and much more work is needed.

THE properties of glass in the annealing range have received much study in the past few years, particularly at the Bureau of Standards, and several curious facts have been ascertained which may have an important bearing on glass manufacture in the future. An especially important contribution to glass technology was the study of the annealing of glass by Adams and Williamson, which not only laid an adequate theoretical basis for the subject, but also outlined a method for determining the constants of any glass and the most efficient annealing procedure.

Since glass is an undercooled liquid it is important to know the freezing points of glass mixtures, and the effect of change of composition on the freezing temperature. This has been done for the important soda-lime glasses by Morey and Bowen, who have shown that the successful glass compositions are all near to the lowest melting of all mixtures of soda, lime and silica, the ternary eutectic between sodium disilicate, quartz and the compound $Na_2O.3CaO.6SiO_2$, and that glasses as a whole are free from devitrication troubles in their working range because they are above their melting point. This explains the fact that the ordinary glass of today differs but little in composition from that made by the early Eglptians; the compositions used by them, and still used, are the only ones that can be used without devitrification.

Researches in Glass at Mellon Institute

By E. Ward Tillotson

Assistant Director, Mellon Institute of Industrial Research, Pittsburgh, Pa.

INVESTIGATIONS on glass, glass technology and refractories used in glass-making furnaces have been in operation at Mellon Institute since its foundation. Dr. Robert Kennedy Duncan, the founder and first director of the Institute, was himself interested in glass and was granted four patents (U. S. Patents Nos. 748,849-50-51, and 772,876) relating to methods of decorating glassware.

The first of the fellowship investigations, conducted by S. R. Scholes, was a study of the elimination of striae in fine glassware. The result was an improved glass pot (U. S. Patent No. 1,200,889), which has proved to be of industrial value, particularly for making lead potash glasses. Dr. Scholes also contributed to the literature of pressed and blown glass tableware, and to the determination of the arsenic and manganese content in glass.

In 1916, A. E. Blake commenced a fundamental study of clay mixtures for tank blocks and pots. A year later M. G. Babcock was appointed as holder of this fellowship and at the end of two years was taken into the donor's employ. His successor, J. L. Crawford, is the present fellowship incumbent. This investigation has resulted in improvements due to better selection of clays and in improved methods of fabricating and processing the product, and due to it is the adaptation to certain glass-making operations of the newer "super" refractories.

Special refractories for a particular glassmaking process have been studied since 1917 by R. W. Miller and E. J. Casselman, successively. This investigation, too, has produced results of value which, however, are held as confidential by the donor.

Translucent glass for lighting ware was the subject of an investigation by R. R. Shively. Among the important developments of this inquiry was the production of a low-expansion translucent glass of superior heat-resisting properties and possessing unusual light transmitting and diffusing properties. R. R. Shively and J. F. W. Schulze have also made studies of tank furnace operation and control for the production of glass for automatic machines.

Colored glasses have been the subject of investigations by H. G. Elledge and E. E. Bartlett, and F. F. Rupert has recently completed a two-year research on the silvering of mirrors.

J. H. Waggoner has lately commenced an investigation that has for its objective the development of glasses possessing particular physical characteristics. Problems in industrial engineering in glass refractories were studied by A. H. Stewart during a period of six years. At the end of that period he entered the employ of his donor.

Altogether the researches in glass at Mellon Institute constitute one of the most extensive series of investigations conducted there in a single industry and include some of the most successful of the researches carried out under its auspices.

Sheet and Plate Glass Industry Makes Rapid Progress

By J. W. Cruikshank
Consulting Engineer
Pittsburgh, Pa.

THE PROGRESS and development made during the last twenty-five years in the manufacture of glass has for its underlying factor the application and utilization of power. Methods of working things out mechanically, and replacing manual labor, have been an engineering problem, the solving of which has brought the glass industry to a basis of greater perfection and higher production than formerly. When wages were low and labor unorganized, the usual answer to a proposal for substituting machinery for labor was that there would be nothing gained in the manufacturing cost. There are now other factors: the humanitarian point of view, the freedom from labor troubles by employing machinery and often the better and more reliable work performed by machines with uniformity in the product. Twenty-five years ago the writer remembers an argument relating to a proposal to put in machinery for digging the sand from the fine sand pits of a plate glass factory and the wheeling it to the grinding machines. This digging was done by one man and therefore his replacement by machinery would not be economical from a cost basis as seen at that time, and, it was argued, why put in more or less expensive machinery to do away with this labor. The answer now comes in the very complete system of grading and handling all the fine sand, in connection with the grinding machines, by means of pumping it to tanks, and the flowing of it back to the machines with a consequent increase in production and more reliable results.

It may be said that the improvement in the casting hall end of plate glass pivoted about the continuous annealing lehr introduced in 1900 and which was gradually adopted by all the factories both in this country and Europe. This apparatus, consisting of five preliminary ovens and a runway some 300 ft. long, anneals and cools the sheets in a period of about three hours against the old method of kilns into which the plates were pushed and lay for forty-eight hours to be cooled down with a mass of brick work that had been heated up to the annealing temperature. The continuous annealing lehr had much influence on the introduction of mechanical manipulation for casting the sheets because the casting table remained in one place, and the glass was delivered to another point where it was cut and manipulated close to the storage racks.

The fixed location of the casting table at the lehr enabled it to be watercooled by means of a series of pipes embedded in the cast iron slabs forming this table. Previously care had to be taken to alternately cast on each end of the table to prevent unequal warping.

The glass plate was formerly cut on a table having a plain wooden top onto which it was pulled from the interior of the kiln by means of a rope previously wound on a hand operated winch, a man having crawled on his hands and knees 60 ft. to the back end of the kiln to hitch a rope to the end of the glass plate. By contrast the cutting table receiving the glass at the end of the lehr is now arranged so that the plate can be manipulated on rollers in either direction for cutting, and the whole can be tipped up into a vertical position for taking away a large sheet. Here overhead carrying means are brought into use, and a sheet is quickly conveyed by a very small gripping clamp suspended from an overhead traveling crane, which raises the sheet and places it in the rough rack where it is ready to be transferred to the grinding machinery.

In plate glass manufacture the melting pot is of supreme importance and much work has been done in selecting suitable clays that will stand up under the increased furnace temperatures and efforts to increase production. The drying of the pots is a most important item toward prolonging their life. A recent development has been that of drying them in a continuous kiln where humidity is supplied to keep the outsides moist and allow the moisture to come out from the inside of the clay body. This drying is effected in one week against six months time that was formerly necessary under ordinary air drying conditions. A further notable accessory in connection with the pots is that of the continuous tunnel kiln in which these pots are now burned.

Furnace refractories are receiving much attention and there is considerable laboratory investigation into the use of sillimanite, mullite and substances that will not be readily attacked by the glass fluxes. The application of superior refractories that will stand higher melting temperatures, and will resist corrosion is of the greatest importance to the industry. Their use will enable the manufacturer to produce harder glasses which require higher temperatures for their production, as well as facilitate the manipulation of glasses whose composition has a highly corrosive action on the refractory clays.

The most talked of development in plate glass is that which originated at the Ford Motor Co. In 1920 there was a shortage of plate glass partly due to the war and to the increased demand for the closed automobile. Henry Ford believed he could revolutionize the methods of plate glass manufacture and started to develop the so-called continuous process which consists in flowing glass from the continuous melting tank in a ribbon, and then placing it on continuously traveling tables on which

it is ground by a series of grinding heads followed by polishers. This system has been a success for small glass and the Pittsburgh Plate Glass Co. are operating a plant of this kind at Creighton, Pa.

In the window glass field in 1900 the glass was all blown by the hand method, which may be said to be probably the most skillful manual operation in any industry. From a ball at the end of the blow pipe the blower developed a cylinder 20 in. in diameter, 8 ft. long and some hundred pounds in weight for double strength glass by alternately blowing and swinging. The cylinder drawing machine worked out by John Lubbers was developed and perfected by the American Window Glass Co. under the management of W. L. Monro, at the plants of which company cylinders of 30 in. in diameter and 42 in. long are now produced, afterwards cut into lengths which are split into three parts or "shawls" for flattening into sheets.

Fourcault commenced work in Belgium in 1910 on drawing sheets of glass vertically from a slot in a clay block floating in the glass, continuing the upward movement and annealing it in a vertical lehr. His early attempts were so promising that the foreign plate glass syndicate entered into a contract with him and paid him a subsidy not to draw glass of over one-eighth inch thickness, fearing competition with their plate glass product. The process, however, was for a long time far from perfect and it is only during the last few years, and still more recently in this country, that it is developing into a success.

The Libbey Owens Machine Co. have developed the sheet drawing machine of Irwin W. Colburn, who experimented for years at Franklin and Falls Creek on a continuous sheet drawing machine. This machine is now successfully producing sheet glass of good quality. The process, unlike the Fourcault, consists in drawing the glass vertically from an extension to a tank, turning it over a roller and then passing it horizontally through an annealing lehr equipped with a series of rollers.

Glass Container Art During Past Twenty-five Years

By H. L. Heintzelman
Former President, Monongah Glass Co., Fairmont, W. Va.

THERE have been three distinct and outstanding developments in the glass container art during the last twenty-five years which, in my opinion, stand out as landmarks in the march of progress. These are, first, the Owens bottle machine; second, suspended gob feeding; and third, a new type of annealing lehr.

The Owens bottle machine came in to commercial use just about twenty-five years ago, and it constituted one of the most far reaching improvements found in any art. This machine drew the molten glass directly into the blank mold, without the use of a separate feeding device, and it turned out bottles practically the equal of those which had been made by hand, without any hand operations whatever, and at a speed many times faster than could be hoped for from any handworker. It was first in the field and attracted much attention.

Since that time, there has been no single improvement in bottle-making machines which approached the Owens machine in importance. Other types of bottle making machines have been improved greatly, both in speed and quality of product, but this improvement is the result of a number of steps, no one of which in itself was at all revolutionary, and these steps, taken individually or in the final result, did not depart radically from the general principle of early bottle machines of their general type. Recently, I have seen a new machine, not yet on the market, which is of a new type and has a production speed considerably greater than that of machines now in use.

The first automatic glass feeder, for delivering shaped compact charges of glass to a mold or other receptacle, was demonstrated to me in 1913 by the inventor, Karl E. Peiler, and thereafter I had the opportunity to observe its commercial development at the Monongah Glass Co., Fairmont, W. Va. Previous to that time, an automatic feeder, known in the trade as the Brooke flow device, had been in use for several years.

The particular advantage of the suspended gob feeder over the Brooke flow device, which was fairly well known in the trade, was that this gob feeder delivered a compact chunk of glass of the desired shape, which was cut from a suspended mass in which there had been no folding, coiling, or chilling, to result in defects. This gob feeder did not make such a spectacular entrance into the field as did the Owens machine due, probably, to the fact that it was put into commercial operation more gradually.

Only a few years ago, a glass annealing lehr was an immense brick oven or tunnel, 10 to 15 ft. wide and 65 to 80 ft. long. A large amount of fuel was required to bring this mass of brick up to working temperature and to keep it there. The variations in temperature longitudinally of the tunnel could be controlled only in the most haphazard manner, thereby making it the common practice to run the lehr at such a rate that the ware went through in anywhere from four to eight hours, so as to be sure that it was fairly well annealed, notwithstanding unknown variations in the temperature to which it was being subjected.

About three years ago, an entirely new type of lehr was brought out by the Hartford-Empire Co. This device was about the same length as those previously used, but it was only about four feet wide, and it was constructed almost entirely of metal. This permitted the lehr to be placed close to the forming machine, which was a distinct advantage, doing away with the long distances through which the ware had to be carried in. Mechanism was provided by which the heat in any part of the lehr could be accurately controlled, thereby permitting the ware to be heated and cooled at the most rapid rate permissible, which resulted not only in more consistently good annealing, but in reducing the time required for annealing to somewhere around an average of perhaps an hour and a half.

The selection of these three improvements should not be taken as an attempt to belittle the vast number of other inventions and improvements brought forward during this time. Many of these were of great importance and value, but I do not consider any of them to approach what might be called an epoch-making improvement.

Soap Making Becomes a Chemical Engineering Industry

By Oscar H. Wurster

Wurster & Sanger, Inc., Chemical Engineers, Chicago, Ill.

WHEN one reflects over the chemical engineering progress that has been made in the soap industry during the past twenty-five years the first reaction is that there have been no outstanding achievements to discuss. This thought probably results from several reasons. The basic methods used today are those which have always been used. Another reason is that we are probably still too close to the picture and it is, therefore, somewhat difficult to get the proper perspective.

There have been numerous important technical developments and contributions to the soap industry and there has been considerable valuable chemical engineering work done. Previous to twenty-five years ago soap was "just made," to use an expression which was given to the writer recently by one man who has spent a lifetime in the soap industry. The number of technical men in the soap industry twenty-five years ago was still rather limited. A few of them had reached relatively important positions in the operation of the plant but the technical man had not reached the responsible executive positions. The importance of this in considering technical progress lies in the effect which it had upon the standing of the technical man in the plant. As the chemist and chemical engineer advanced to the important positions both in the plant and in the executive departments, the manufacture of soap gradually became a thoroughly organized chemical engineering industry, operated under chemical supervision and control.

It is probable that this great improvement in the control of the processes for preparing the raw materials and for manufacturing the soap must be considered as the great achievement in this industry of the past twenty-five years. In going around to soap factories in the present day one no longer hears the complaints and discussion of the difficulties of making and finishing a boil of soap. The making of a kettle of soap in large plants now goes forward with clock-like precision on a tremendous scale and one kettle is finished as another. Twenty-five years ago a favorite subject of discussion of the old soapmakers was the feat of making and finishing a kettle of soap and the difficulties encountered therein. This is now most decidedly a thing of the past. The equipment has been perfected so that better and more positive control is possible and the operations are in charge of technical men who understand the underlying reactions and, therefore, know how to control the various factors to bring about the desired results without meeting any of the difficulties that formerly gave trouble.

Important chemical achievements in the period under discussion are the invention of the Twitchell process for splitting fats and the hydrogenation of oils. While both of these processes must be looked upon as of first importance in the fat and oil industry as a whole, their influence on the soap industry has been largely indirect and possibly of secondary importance. Dr. Ernest Twitchell of Cincinnati developed the process which bears his name and is now used the world over. Robert E. Devine was later manager of the Twitchell Process Co. and carried on further development work. Of the several methods of fat splitting for the production of fatty acids, the older autoclave process and the Twitchell process are the only ones which have been extensively used in this country and the Twitchell process has now largely displaced the autoclave process. The process is used in the splitting of low-grade fats and oils to be distilled and also for saponifying good qualities of fats for the production of stearic acid and red oil.

The development and perfection of the equipment and processes used in oil hardening and in producing catalyzers for this purpose was taken part in by so many that to give the names of those who did this work would be to give a list of almost every prominent chemist and chemical engineer connected with the fat and oil industry. The use of hardened fat has found but limited use in the soap industry. At times fairly large quantities of hardened whale and fish oils have been used. But the extensive use of hydrogenated oils for edible purposes has undoubtedly had its effect upon the raw material market of the soap manufacturers, since it has widened the demand for these materials.

Considering the products of the soap industry, the tendency has been toward the elimination of bar soap as a laundry soap and the increased use of chip soap and soap powders. These new forms of products have, in turn, had their effect upon the development of processes and equipment, some of which have been mechanical and others have been entirely of a chemical engineering nature. Spray processes have been developed for the production of soap powders and powdered soap. John C. Ingram and J. A. Schwantes have done work in this field. Early work in the development of one of the older methods of manufacturing soap powder was carried out by Archibald Campbell and C. P. Long.

The use of chip soap by laundries was followed closely by soap flakes for household use. This is largely a mechanical development which was brought to this country from England. The popularity of flake soap has

J. R. POWELL

The present assistant general manager of Armour & Co., entered that organization in 1905 and for 21 years has been identified with the chemical and engineering advances made in the Armour soap, glue and ammonia works. His work on preventing rancidity has been most important.

N. N. DALTON

Prominent among executives in the soap industry who have begun their careers as chemists or engineers is N. N. Dalton, who for years has been identified with Peet Brothers. Since consolidation with the Palmolive company, Mr. Dalton has been vice-president of Palmolive-Peet company.

CARLOS P. LONG

Completing his undergraduate and post graduate work at Michigan in 1906, Mr. Long went with the Globe Soap Co. of Cincinnati as a chemist on July 1 of that year. He is at present the chemical director. With Archibald Campbell he carried on early work on manufacturing soap powders.

E. G. HOLLOWAY

The president of James S. Kirk & Co. has been prominently connected with chemical engineering developments although he is not a chemical graduate. He entered the employ of his company as a laborer but by self-training in chemistry prepared himself to hold responsible positions.

been so great that this product now has a large market. J. R. Cove developed some of the equipment for this product.

An important study in the causes of rancidity of soaps has been carried out by J. R. Powell and Robert E. Devine. This work has resulted in definite methods of preventing rancidity.

There have been important developments in the processes and equipment for the recovery and refining of glycerine. The late William Garrigue invented the closed system for distilling glycerine and the late Walter E. Sanger developed subsequent improvements of this system. Improvements in the design of evaporators for the concentration of spent soap lyes were also made by Walter E. Sanger.

The distillation of fatty acids under vacuum has been a development of the period under discussion. The early methods and equipment were relatively crude. The design of the equipment and the plant as a whole has been improved and simplified in recent years so that the operation is controlled and the products and yields are consequently improved.

Who are the men who are responsible for the chemical engineering progress made in the soap industry in the past twenty-five years? If you ask some of these men who have spent a lifetime in the soap industry what they have accomplished, the answer comes rather hesitatingly. They, also, find it difficult to point to one or two outstanding achievements simply because they have done their part in their own organizations in the sum total of the development which has taken place in the industry. We believe, therefore, that to account for the entire technical advance which has been made in the industry we must give credit to those men who have contributed a lifetime of study and energy to solving the routine and special technical problems arising from day to day within their own plants and organizations.

In the Procter & Gamble organization the names which come to mind are those of H. J. Morrison, R. K. Brodie, Procter Thompson and R. A. Duncan.

In the Armour organization there are J. R. Powell, now Assistant General Manager, D. M. Flick, General Superintendent, J. F. Johnson, Technical Director, and John C. Ingram, Superintendent.

Dr. W. D. Richardson, Horace F. Taylor, W. H. Irwin and Robert Groundwater have carried on the work at the soap plant of Swift & Co.

Dr. Martin H. Ittner and D. W. Taylor have carried on their work at the plant of Colgate & Company. N. N. Dalton, also chemist, is now vice-president of the Palmolive-Peet Co., J. A. Riley is general superintendent and V. K. Cassidy is chief chemist. E. G. Holloway, starting as a laborer and then studying chemistry, is president of Jas. S. Kirk & Co., and Walter R. Kirk has been closely connected with this company for many years, at the present time serving as director.

At the plant of William Waltke & Co., are H. J. Boulden, superintendent, and his son, John Boulden. At the Lever Brothers' plants are J. R. Cove, J. W. Hegeman, J. W. Bodman and W. H. Harbey. Alfred Garrigues is superintendent of the Manhattan Soap Co., and W. S. Rapelje of Kirkman & Son. E. T. Marceau and R. M. Donald are with the Gold Dust Corporation.

Burrows Morey is manager of the soap department and L. H. Hoyt is chief chemist of the Larkin Co. at Buffalo. George A. Wrisley, chemical engineer, is manager of the Allen B. Wrisley Co. plant at Chicago.

Frank H. Merrill is president of the Los Angeles Soap Co. Dr. Jacob Goldbaum is with Fels & Co., and G. W. Eisenlohr and Howard Dock are with the M. Werk Co. G. R. Fulton is president of the Kendall Mfg. Co., and Messrs. Best and Ray are with the Potter Drug & Chemical Co. Andrew Jergens, Jr., is manager of the Andrew Jergens Co. Dr. Wilson H. Lowe was for many years chief chemist of the Cudahy Co.

In addition to the names mentioned above there un-

FRANK H. MERRILL

1927 marks the 34th year of Mr. Merrill's connection with the soap industry. Following his graduation from M.I.T. in 1893 he served as chemical engineer for Jobbins & Van Ruymbeke, glycerine equipment manufacturers. Since 1897 he has been with the Los Angeles Soap Co., now as vice-president and general manager.

Boye Portrait

BURROWS MOREY

As a chemical graduate of M.I.T. in 1906, Mr. Morey began work with the Larkin company in its research laboratory and from 1908 to 1920 directed the laboratory and later, the research department. He served as superintendent of Buffalo Leather Co., 1911-12 and has managed the Larkin soap department since 1920.

Photo by Beach

H. J. MORRISON

Since joining Procter & Gamble immediately after graduating from Yale in 1887, Mr. Morrison has served as head of all of its manufacturing departments. He was chemical superintendent in 1912 when the Chemical Division was established and is now special chemical consultant to the company.

Backrach

WALTER S. RAPELJE

Since 1919 Mr. Rapelje has been superintendent of Kirkman & Son of Brooklyn but 15 years prior to that time he made his first connection with the soap industry, serving as assistant chemist for B. T. Babbitt. He was chief chemist for Kirkman from 1910 to 1913 and then served for 6 years as assistant superintendent.

doubtedly are others with these organizations as well as with other organizations who have done their part of the work in the development of the soap industry. It would probably be impossible for any one man, without an extended correspondence which was not possible in this case, to determine the names and the details of the work of all the chemists and chemical engineers who have made valuable contributions to the advancement of the industry within their own plants or to the industry as a whole.

As a result of all the work referred to above, the soap industry is now a highly developed chemical engineering industry which has linked closely with it the recovery and refining of glycerine, the distilling of fatty acids and the hydrogenation of oils. As a direct result of this improvement of technical control, refinement of processes and preparation of raw materials, the products are also considerably improved in many respects and of better quality than they were twenty-five years ago.

The improvement in the general technology of manufacture has resulted in economies of production which have been passed on to the consumer. The price of soaps to the consumer has advanced but a small fraction as compared with the advance in costs of raw materials and labor. It is probable that no other product in common use has been improved to the extent that the products of the soap industry have with as little advance in price.

During the war the soap factories of this country were called upon to supply a large part of the world with soaps, a condition which existed in some other industries as well. The increased manufacturing capacity led to very keen competition in the post-war period and this has been a serious disturbing economic factor in the soap industry since the war. The industry, however, now holds firmly and substantially its position as a highly developed chemical industry acquired during the past twenty-five years of chemical engineering progress.

Use of Liquid Chlorine in America

THE FIRST commercial American liquid chlorine was manufactured in 1909 and was shipped in steel cylinders of German manufacture, containing 100 lb. each. The business grew slowly but surely, largely through the pioneer efforts of E. D. Kingsley, who spared no effort to interest, first, the bleachers of cotton textiles and, a little later, municipal water works which had already, in a few cases, begun to treat potable water supplies with bleaching powder.

In 1909 the first American 15-ton tank car for railroad transportation of liquid chlorine was put into service, the chlorine being used in the detinning of scrap tin. Cylinders containing 150 lb. came into use and, in 1917, the U. S. Army Chemical Warfare Service used a 1-ton container. Still later, a car holding fifteen of the 1-ton tanks was put into service. In the American industry at this time over 300 tank cars of both types and 80,000 cylinders are in use. The transportation of liquid chlorine is regulated by law in the United States. The regulations are elaborate and are rigorously enforced and great quantities of liquid chlorine are transported and handled yearly with absence of accident.

A technic in the application of chlorine, on release from the containers, has been built up. This shift from bleaching powder to chlorine illustrates well the modern tendency in chemical industries to use elemental or simple substances in concentrated form.—*Journal of Chemical Education.*

Chemical Engineering Progress in Petroleum Refining

In 1885, with the discovery of Lima oil, there was scarcely one trained petroleum chemist in the United States. The oil refiners, however, were forced to turn to the chemical profession for the solution of their problems, and the chemists had to become somewhat trained in the refining business before they could offer a practical solution for the elimination of sulphur from oil. This was the starting point for a better feeling toward the chemical profession

THIS STATEMENT, made in 1918 by Dr. William M. Burton, goes back beyond the period under discussion, but by contrast, it gives an interesting background for the many impressive chemical and engineering developments since 1902. When Burton left Johns Hopkins to begin his work with the Standard Oil Co., Herman Frasch—the outstanding chemical engineer of his day—had just developed at the Clark works of the Standard Oil Co. at Cleveland, Ohio, the historic process for desulphurizing petroleum that made possible the utilization of Lima oil. While in College, Dr. Burton had also been working on the sulphur problem under Professors Remsen and Morse, and it was along this line that the first chemical work was started at the Whiting, Indiana, refinery.

Whiting soon became a recognized center of chemical activities in the oil industry and from 1902 until 1907 there accumulated there a small group of investigators including such well-known petroleum chemists as Dr. R. E. Humphreys, the present assistant general manager of the manufacturing department of the Indiana Company. Dr. George W. Gray, now assistant manager of refining for the Texas Company and Dr. F. M. Rogers, the present chief chemist at Whiting. Among other chemists employed at Whiting during this period were Dr. R. H. Brownlee, now a prominent consultant in Pittsburgh and Dr. B. F. Carver in charge of the chemical laboratory of the Standard Development Co., at Bayway, N. J.

But real chemical progress was also being made in the refineries along the Atlantic Seaboard, although lacking the concentration evidenced at Whiting, developments were perhaps less conspicuous. Among the chemists, engineers and practical men directing work along chemical engineering lines in the Eastern refineries were the late George M. Saybolt, chief inspector for the Standard Oil Co., and Clarence I. Robinson and E. B. Cobb, who have since held a succession of chemical positions with the Standard Oil Co., of N. J. Others of this group included William Irish, J. W. Van Dyke and F. C. Robinson at the Atlantic refinery in Philadelphia, George H. Taber, previously at the Atlantic but who in 1905 was general manager of the Gulf Oil Co. and J. N. Pew, president of the Sun Oil Co. of Philadelphia, who was later succeeded in that position by his son, J. Howard Pew.

Many chemical and engineering developments were also under way at the Tidewater refinery at Bayonne, where the late P. R. Gray had served in process work from 1884 to 1910. Mr. Gray's name has been conspicuously identified with chemical engineering developments in the petroleum industry for the past fifty years. He reared and educated a family of eight sons, six of whom are actively connected with the oil business. The oldest son, E. B. Gray, who served as Chief Chemist at Tidewater until 1904, is now superintendent for the Barnsdall Refining Co. The second son, P. R. Gray, is chief engineer for the Gray Processes Corporation of Newark. A. McDowell Gray, whose name is associated with the Gray wax chiller, press and molding equipment, is the third son. The fourth, John L. Gray, is vice-president of the Shaffer Oil & Refining Co., of Tulsa, and the fifth, is McDowell Gray, with the Marland company at Ponca City, Okla. Thomas T. Gray, the inventor of the Gray vapor phase refining process, and president of the Gray Processes Corporation, is the youngest son in this distinguished group. In 1904 he had succeeded his brother, E. B. Gray, as chief chemist for the Tidewater Co., which position he held until 1915.

Gasoline in those days represented only about 10 per cent of the volume of crude oil run to the stills and it was not until about 1910 when the automobile developed a greatly increased demand for motor fuel, that the petroleum industry became interested in the possibilities of the cracking process as we know it today. The first real commercial equipment built and operated entirely for cracking petroleum, was that put into successful operation by Dr. W. M. Burton in the summer of 1912. Six months later the first of the Burton patents (No. 1,049,667) had been issued and a few months after that forty stills were in operation at Whiting. Commercial cracking practice is, therefore, only fifteen years old but during that brief period it has had a tremendous development. C. L. Parmelee, consulting engineer of New York, is authority for the statement that in 1926 there were twenty-six different cracking

processes in commercial operation, each running 100 or more bbl. of charging stock per day. In addition, there were twenty-eight commercial sized experimental or demonstration units in occasional use. Over 2,500 United States patents had been issued on cracking up to February, 1926, and about as many more applications were pending.

In the development of the Burton process, a difficulty that at first seemed insurmountable was the accumulation of carbon which deposited on the bottom of the still and caused overheating. It was not until Dr. R. E. Humphreys had introduced a false bottom of movable steel plate in the still, in order to collect most of the carbon, that this problem was finally solved. Further improvements to the Burton process were made by E. M. Clark, the most important being the replacement of the shell still by a tubular still constructed on the principle of the Heine boiler. This greatly increased the output because of the larger heating surface and because the rapid circulation through the tubes reduced the carbon deposition on the heating surface.

Of the cracking systems other than the Burton, that have been successfully operated on a large scale, the most widely adopted includes the process developed by Carbon Petroleum Dubbs which is owned by the Universal Oil Products Co., of Chicago, the Cross process, of which Dr. Walter M. Cross and Dr. Roy Cross of Kansas City, Mo., are the inventors, the Holmes-Manley process, that gets its name from R. C. Holmes, president of the Texas Co., and F. T. Manley, former refinery manager of the Texas Co. and the so-called tube-and-tank process of the Standard Oil Co. of N. J., which was invented by Carleton Ellis and has since been developed by engineers in the Standard organization. Isom equipment used by the Sinclair Refining Co. takes its name from Edward W. Isom. The Fleming process developed by Richard Fleming of New York, is in use at the Marland refinery at Ponca City, Okla., and elsewhere, but has had little growth in recent years. The Hall, Rittman and Greenstreet processes, once well advertised, have had little or no recent commercial development. The Jenkins process of the Graver Corporation, and the Doherty process of the Empire Refineries, have more recently attracted attention. Among chemical processes the aluminum chloride method developed by A. M. McAfee and George W. Gray, has been utilized by the Gulf Refining Co.

For many years it had been universal practice to distill crude petroleum in a number of steps, each of which involved a consequent loss of product as well as increased cost due to fuel, etc. It was a revolutionary step, therefore, when in 1905 William Irish and John Van Dyke, using their air-cooled, stone-packed tower, first distilled crude oil to coke in a single step. Twelve stills put up at the Atlantic refinery in Philadelphia attracted wide attention and after being tested out by a committee of refinery superintendents early in 1907, the method was widely adopted in the industry.

The continuous distillation of crude oil to a 15 per cent bottom using a battery of shell stills connected in a series was also first practiced at Philadelphia about the same time or just prior to the Van Dyke development.

Perhaps the next most important development in petroleum distillation was the introduction of the tube or pipe still with which the name of M. J. Trumble and the Shell Co. of California is generally associated. At first used on the Pacific Coast primarily for dehydrating and stripping purposes on crudes of low-gasoline content, the pipe still soon demonstrated its advantages over the older shell type still for many operations, including pressure distillation. C. L. Parmelee, in commenting on the tendency towards the exclusive use of tubular units in cracking, points out that in 1925 over 70 per cent of the throughput was so treated, while in 1926 the proportion probably exceeded 80 per cent and has continued to increase.

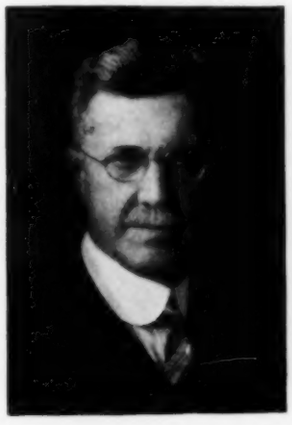
The necessity for closer fractionation of petroleum products and the avoidance of re-running did not impress itself seriously upon the refiners until the industry

CLARENCE I. ROBINSON

Graduating from Cornell in the class of 1884, Mr. Robinson began his connection with the oil industry in the spring of 1885 when employed by the Acme Oil Co. of Olean, N. Y. Until his recent retirement he had long been in charge of the chemical laboratories of the Standard Oil Co. of N. J.

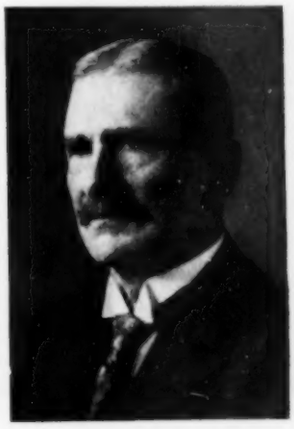
ROY CROSS

Dr. Roy Cross, whose name is associated with that of his brother Dr. Walter M. Cross, in the invention and development of the Cross cracking process has long been identified with the petroleum and natural gas industries at the Kansas City Testing Laboratory and the Cross Engineering Co.



ROBERT E. HUMPHREYS

After receiving his doctor's degree from Johns Hopkins in 1900, Dr. Humphreys entered the employ of the Standard Oil Co. as a chemist at Whiting and has since held a succession of responsible positions leading to his present office of director and assistant general manager of manufacturing.



CHARLES F. MABERY

This month marks the fiftieth anniversary of the appearance of Dr. Mabery's first paper on petroleum and during that period he has devoted more time in investigation and has published more papers on American petroleum than any contemporary. His latest work is on lubricants.

THOMAS T. GRAY

Mr. Gray's twenty-seven years continuous experience with the petroleum industry has been divided between the Tide Water Oil Co. where he was chief chemist until 1915 and in consulting work for various companies and for the U. S. Bureau of Mines. He is the inventor of the Gray vapor phase refining process.

THOMAS MIDGLEY, JR.

Graduating from Cornell in 1911 as a mechanical engineer, Mr. Midgley was connected with the rubber industry until joining the General Motors research organization just prior to the war. In the latter connection his work on motor fuels resulted in his discovery with T. A. Boyd of tetraethyl lead.

E. B. COBB

Serving the Standard Oil Co. of New Jersey in a succession of chemical positions, Mr. Cobb had an important part in the work of developing the production of medicinal oils in the United States. Prior to this time such products were imported from Germany although we were the largest producers of petroleum.

ROBERT E. WILSON

While director of the research laboratory at M.I.T. (1919-1922), Mr. Wilson worked on refining problems for the Vacuum Oil Co. and the Standard Oil Co. of N. J. and on motor fuel problems for General Motors. Joining the Standard of Indiana in 1922 he has had charge of research and development work. *Ray Studios*

set about to meet the growing post-war demand for motor fuel. Gasoline consumption was going ahead at a faster rate than crude oil production and every manufacturing economy was called into play. About 1920 the attention of some of the larger refineries was called to the fact that more efficient distillation was being practiced in other industries, notably alcohol manufacture and in the refining of benzol and other coal-tar derivatives. One of the first proposals was the use of a fractionating column with the sieve type of plate which was tried out in one of the Eastern refineries and, although working successfully when operated at constant pressure, was finally abandoned in favor of the bell-cap type that has since become known in the industry as the "bubble tower." It is of historical interest to note in this connection that Herman Frasch had been thoroughly familiar with this type of fractionating tower which had been used by Professor Heckmann in Germany for the refining of cleaners' naphtha about 1870 or 1875. Frasch conceived the idea of building a vacuum steam still with a Heckmann tower and drew up plans for such a unit in 1898. However, it was turned down by his company in favor of a stone-packed tower which was put into use by the Standard Oil Co. in September, 1900.

In the return of the petroleum industry's interest in improved fractionating equipment those who have figured most prominently in the development include Professors W. K. Lewis and Clark S. Robinson of the Massachusetts Institute of Technology, W. A. Peters, Jr., of E. B. Badger & Co., Prof. E. H. Leslie and associates at the University of Michigan, R. E. Wilson and associates in the Standard Oil Co., at Whiting, W. C. Koehler, Dr. N. E. Loomis and the engineering staff of the Standard Development Co., C. J. Von Bibra of the General Petroleum Corporation, J. M. Wadsworth of the Pierce Co., and many others.

Vacuum distillation, particularly as applied in the steam distillation of lubricating oils is one of the oldest refining processes. Only since 1920, however, has the use of high vacuum (operating pressures of from 3 to 7 mm. absolute) become of increasing interest. The Schulze process developed at the Red River Refining Co., by J. E. Schulze and the Zieley process have attracted most attention.

Most of the common refining agents—sulphuric acid, caustic soda, litharge, sulphur and fullers earth were in use by the industry prior to 1900. Fullers earth had replaced animal charcoal (except for certain special products) about 1897-1898, its value first having been recognized in 1893 by George H. Taber at the Atlantic refinery. George M. Saybolt had patented a process for using fine clay to remove the flock from kerosene in 1896, but although used for some time on kerosene and gasoline and to some extent on lubricating oils, the process was eventually displaced by the percolation method using coarser material.

Continuous treating of naphthas came into prominence at the Bayonne refinery of the Standard Oil Co., at about 1913, although prior to that time much pioneer work on continuous acid treating of burning oils had been carried on in the New York refineries under the direction of Henry C. Smart. At Bayonne one of the New Jersey engineers had patented a process that involved a series of reaction towers or chambers in each of which there was a rotating device for mechanical agitation. A break in the agitating equipment accidentally proved that it was unnecessary in the process and mechanical agitation was later dispensed with, thus breaking the patent. The centrifugal pump method of treating naphthas in order to avoid excessive losses was developed at Bayway during the period William C. Koehler was in charge there.

Vapor-Phase Refining. Although the use of sulphuric acid has continued to be the principal method for refining gasoline to remove gum-forming constituents, there has been in recent years an increasing desire to do away with the process because of excessive losses

in both quantity and quality and the objectionable handling, disposal, or recovery of sludge acid. The most promising recent development has been the use of fuller's earth in specially designed vapor-phase treating towers. About 1913 Thomas T. Gray of Elizabeth, N. J., discovered that if gasoline in the vapor phase were brought into contact with fullers earth the tendency for the gasoline to develop color and deposit gums was removed. A selective polymerization took place whereby the polymerized product separated out as a higher boiling liquid leaving the gasoline vapor in a stable, refined condition. A patent was granted on this process in 1920 (U. S. Patent 1,340,889) but it was not until 1924 that the laboratory method was translated to large-scale commercial production at the refinery of the Barnsdall company, at Barnsdall, Okla.

Liquid Sulphur Dioxide. Dr. L. Edeleanu worked out a process in Roumania between 1906 and 1914 in which liquid sulphur dioxide could be used in the refining of petroleum distillates, particularly of kerosene that because of high content of aromatic and other unsaturated hydrocarbons are not satisfactory illuminants. This is the condition met with in the case of certain California crude oils and Dr. Edeleanu has successfully introduced his process in a number of refineries along the Pacific Coast for treating kerosene and to some extent for lubricating oils.

Hypochlorite Treatment. In recent years there has been considerable interest in a treating process using sodium hypochlorite which was developed in England under the direction of Dr. A. E. Dunstan, chief chemist of the Anglo-Persian Oil Co., Ltd. Gasoline and kerosene are successfully treated by this process in England, although in the United States, where the patents are controlled by the Mathieson Alkali Works, most progress has been made in the sweetening of gasoline from natural gas. It is of interest in this connection to note that H. W. Young and A. W. Peake of the Midwest Refining Co., independently developed a successful sweetening method in the spring of 1921 that depended upon hypochlorite in the form of bleaching powder.

Contact Filtration. The so-called contact process of filtering petroleum products involves the mechanical mixing of finely divided materials of high adsorptive value with oil and the subsequent removal of the adsorbent material by means of a filter press. The finely divided fullers earth and acid-treated clays of the bentonite type are most commonly used. There have been a number of contact filter plants constructed within the past few years, the first being on the Pacific Coast where the development originated with the General Petroleum Corporation and the Standard Oil Co. of California.

Anti-Knock Motor Fuel. About 1919 work was begun in the engine laboratories of the General Motors Research Corporation to determine the cause of the knocking that occurs in gasoline engines under certain operating conditions. The research thus initiated finally led to the discovery by Thomas Midgley, Jr., and his associate, T. A. Boyd of the remarkable knock-suppressing property of small quantities of tetraethyl lead when added to ordinary gasoline.

Refined Medicinal Oils. Prior to the beginning of the World War practically all of the liquid petrolatum used in the United States for medicinal purposes came from Germany where it had been refined from Russian petroleum stock. Research chemists and engineers in this country in 1914 and 1915 set to the problem of refining a comparable product from American petroleum. Within a short while a product of a quality superior to the imported was being produced in large quantity. Prominent in this important development was E. B. Cobb of the Standard Oil Co. of New Jersey, under whose name the Nujol (New Jersey Oil) patents were issued.

Natural Gasoline. According to Frank B. Peterson (A.I.M.E. 1918, p. 579) the natural gasoline industry had its inception along real commercial lines in the neighborhood of Kinzua, Pa. A little plant was developed there under the direction of John L. Gray between 1907 and 1910. "In 1910," Peterson states, "it was operating continuously and successfully and in its operation were embodied every detail of development that has been worked out to this date (1918) with the exception of increased pressure." The compression method had become well established before much progress had been made with the absorption process. Although E. D. Leland is accredited with extracting gasoline from natural gas by an absorption process in connection with refrigeration as far back as 1901, it was not until 1913 that the first plant especially designed to operate under the absorption method was constructed at Hastings, West Virginia. The third method, the use of solid adsorbents of the activated carbon type dated from the close of the World War, being largely the result of experience gained in the design and construction of gas masks. The name of Col. George A. Burrell of Pittsburgh is closely associated with this development, and during his prior connection with the Bureau of Mines, he worked on the absorption process with G. C. Oberfell, P. M. Biddison, W. P. Dykema and others.

Alcohols from Petroleum. The olefine hydrocarbons produced in the cracking of petroleum furnish the raw material for the production of isopropyl alcohol in two refineries, and a third plant is producing certain higher alcohols from the same source. The Standard Oil Co. of New Jersey in 1919 purchased certain basic patents issued to Carleton Ellis. The Empire Refineries are licensees of these patents, although independent laboratory research by the Doherty Research Co. had been started in January, 1918. The Petroleum Chemical Corporation formed to exploit the process developed by the Arthur D. Little organization is the most recent to enter this field.

Organized Research. The chemical engineering achievements discussed here, as well as many others to which reference cannot be included, have all resulted from independent and highly competitive effort. The first organized research program for the entire industry was launched during the past year under the sponsorship of the American Petroleum Institute and the National Research Council. This program was made possible by generous appropriations from John D. Rockefeller and the Universal Oil Products Co. Much of the pioneer work for this movement was carried on by a committee and particular credit should be given to Dr. Benjamin T. Brooks, Professor James F. Norris, and Van H. Manning and R. P. Anderson, his successor as director of research for the American Petroleum Institute.

Recent Improvements in Cane Sugar Manufacture

By C. A. Browne

Chief, Bureau of Chemistry, U. S. Department of Agriculture Washington, D. C.

PROCESSES for the manufacture of cane sugar, like those for many other industries, have shown cyclic tendencies. White sugar of high purity was manufactured with the aid of animal charcoal on Cuban sugar plantations seventy-five years ago; in the course of time, however, this phase of the industry disappeared with the changing demands of commerce, and only raw sugar was produced. After an intermission of half a century the manufacture of plantation white and refined sugar has revived, and the newer vegetable decolorizing carbons have found an increasing use. It is difficult at present to prophesy what the final outcome of this revival is to be. There are some who believe that the process of sugar refining must eventually be transferred to the point of production because of the deterioration, expense of bagging and other losses which occur under the present system. Others take an opposite view because of the previous inability of sugar plantations to produce a commodity that is equal in quality to the purest refined sugar. Owing to the injurious effects of traces of impurities when sugar is employed for certain specific purposes, there is an increasing demand, by confectioners and other discriminating users, for products which exceed the purity attainable in a tropical sugar house. Whatever may be the ultimate outcome, the cane sugar refining industry of the United States seems destined to remain for many years upon a stable economic basis.

The improvements in cane sugar manufacture during the past twenty-five years are largely the result of the development of the modern central system. In 1893, 858 sugar factories were in operation in Cuba. The movement of centralizing production in larger, better-equipped establishments had already commenced, but it was interrupted by the outbreak of the Cuban War in 1895. The modern era dates from the reconstruction of the sugar industry in Cuba by American capital at the end of the Spanish War. The innumerable sites of abandoned sugar factories which the visitor sees in Cuba and other West Indian islands are mute reminders of the failure of old uneconomic methods of small units of production. Large-scale manufacture with huge milling equipment, enormous evaporating capacity and immense storage facilities have reduced costs of production to a figure which the little factory with its obsolete three-roller mill and diminutive vacuum pan could never attain. The final inevitable result was a reduction in the number of sugar factories in Cuba from 858 in 1893 to 184 in 1925, with a total increase in production from 816,000 tons to 5,125,970 tons.

The first great development in modern cane sugar manufacture was the improvement in mill construction. This was partly an indirect result of the diffusion experiments of the Bureau of Chemistry which were conducted by the late Dr. G. L. Spencer between 1886 and 1890. In the 1888-89 campaign at Magnolia, Louisiana, 222 lb. of total sugar was obtained per ton of cane by diffusion as compared with 167.9 lb. by milling. The threatening inroads of diffusion forced manufacturers to make a complete reform in the old methods of mill construction. Pretreatment of the sugar cane by crushers or shredders, increase in the size and number of the milling units and improvements in the technique of maceration have enabled some of the large Hawaiian mills in recent years to exceed a 99 per cent extraction. The diffusion process because of the increased requirement of steam, the heavier demand upon labor, and the inferior quality of the cane fiber for fuel, has been unable to compete with the modern high-power mill.

High-pressure milling, however, has brought in its train a number of disadvantages. Much of the bagasse is reduced to a fibrous powder, which finds its way through to the final sugar and by its moisture retaining capacity exerts an undesirable influence upon the keeping quality of the product. High-pressure milling also removes more of the gums and other colloidal impurities of the cane, thereby increasing the difficulties of clarification.

The most recent development in sugar cane milling is the electric drive. The erection of large central steam turbine plants has so lowered the costs of power production that the distribution of electricity for operating plantation locomotives, mills, pumps, centrifugals and crystallizers is now a well established practice in the large factories of latest construction. The electric drive with its saving of space, rapidity of action, lower upkeep and smoother operation, as compared with the engine drive, is rapidly winning its way. The application of the electric drive to mill rolls, which originated in Cuba, has now spread to nearly all the cane sugar producing countries of the world.

The recent inroads of mosaic disease have led to the introduction of newer, more resistant cane varieties of higher fiber content, and this in turn has led to heavier mill construction. The juice of such canes, because of a higher content of colloidal impurities, has led to changes in methods of clarification. Thus, as so often happens, changed conditions in the field may lead to disturbances in the factory and refinery.

Increasing attention has been given in recent years to improvements in the clarification of sugar cane juices. Although every month brings with it the proposal of some new chemical as a clarifying agent, lime still continues to hold the supremacy which it has enjoyed for the past thousand years. Improvements have long been needed, however, for controlling the addition of this agent in order to prevent the injurious action of either under- or over-liming. The constant mechanical control of liming by an automatic hydrogen-ion regulator gives promise of realization and when this is accomplished, one of the greatest difficulties of sugar manufacture will have been removed.

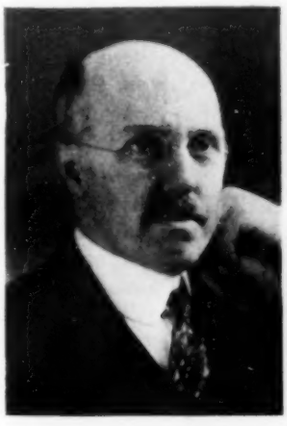
The application of colloidal chemistry to the clarification of sugar solutions is a development of the past twenty years. The presence of uneliminated colloidal impurities is not only responsible for various sugar factory difficulties, such as poor filtration, but it is also a most common cause of off-colored sugar. These impurities may be inorganic as well as organic. In Demerara much colloidal silica finds its way from the soil into the cane juices and causes trouble in the factory by interfering with the clarification and by producing scale upon the coils of the evaporators. Superheating the juice before clarifying with lime has been found to eliminate much of this colloidal silica and to cause a marked improvement in the yield and quality of the raw sugar produced.

It is impossible within the scope of the present paper to enumerate the various devices which have been proposed during the past quarter century for the treatment of sugar juices. The files of the Patent Office in Washington are burdened with the specification sheets of defecators, settlers, clarifiers and filter presses that have had their day and ceased to be. A newly discovered principle of sugar manufacture persists, but the appliances which make use of it are subject to continual change. Rillieux's discovery of multiple-effect evaporation (the greatest technological contribution of any American to sugar manufacture) remains in principle the same as when first announced over 80 years ago, although Rillieux's original evaporator has undergone a countless number of modifications.

Manufacturers of sugar have probably been more imposed upon by the purchase of undeveloped and impracticable patented processes and appliances than have those of any other product. It is instructive to visit the sugar factories of Cuba and other sugar producing countries and to note the expensive equipment discarded after brief use as uneconomical or useless. The sugar planter has always shown willingness to adopt any suggested improvement, whether it be a new appliance, such as a filter press or evaporator, or whether it be an entirely new process of manufacture. When the new scheme is backed by capital and well-organized propaganda, the isolated manufacturer is almost helpless if he desires to ascertain the disadvantages of the proposed innovation. Too often in cases of this kind the purchaser has been sold a problem instead of a well-developed process. Trade publications should throw their columns open to a free discussion of the pros and cons of every process in which both the successful and unsuccessful users can state their experience, for it is only upon the basis of widely disseminated experience that progress can be made.

The use of infusorial earth as a mechanical aid in filtration, first proposed by the late Dr. F. G. Wiechmann, has now come into frequent use in sugar refineries but is not employed to any great extent in the production of raw sugar. Paper pulp, wood meal and other materials have also been proposed to assist the removal of very fine suspended impurities.

Hydrosulphite preparations which attracted so much attention twenty years ago as bleaching agents in the



C. A. BROWNE

After serving in the Bureau of Chemistry, C. A. Browne became chemist in charge of the New York Sugar Trade Laboratory, a post he held from 1907 to 1923 when he returned to the Bureau of Chemistry as chief. In 1925 he received from the Stevens Institute of Technology the honorary degree of Doctor of Science.

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G. L. SPENCER

Forty years of Dr. Spencer's life was spent in the technology of sugar, first in the U. S. Department of Agriculture, and later as chemist, chief chemist and consultant to sugar enterprises in Louisiana, Cuba and Central America. From 1906 until his death in 1925, Dr. Spencer was chief chemist of Cuban-American Sugar Co.

Alman & Co

F. W. ZERBAN

F. W. Zerban has long been prominent in sugar technology, a field in which he has contributed much to the periodical literature. After his connection with Penick & Ford, Ltd., Marrero, La., as research chemist, he came to New York to succeed Dr. C. A. Browne as chemist in charge of the New York Sugar Trade Laboratory.

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H. C. PRINSEN-GEERLIGS

For many years Dr. H. C. Prinsen-Geerligs of Holland has been a contributor to the periodical and book literature of sugar technology. His first book, "Cane Sugar and Its Manufacture," was published in 1909. He subsequently wrote "Practical White Sugar Manufacture," a standard work, and "The World's Cane Sugar Production."

manufacture of white sugars and sirups have fallen into disfavor. The bleaching effect obtained with hydrosulphite compounds was found in most cases to be only temporary, the sugars and sirups so treated resuming their objectionable color upon exposure to the air. Vegetable decolorizing carbons have largely supplanted hydrosulphites as decolorizing agents in plantation white sugar manufacture, the products from properly treated and filtered juices showing no falling off in brilliancy of color. A defect of certain vegetable charcoals has been their tendency to disintegrate into a fine dust during revivification with a consequent loss of material and also with an increasing tendency to run through the filters and impair the brilliancy of the resulting sirups and sugars. A new process of revivification by means of a revolving electrical furnace is said to obviate this difficulty to a considerable extent.

THE history of vegetable charcoals for sugar manufacture in the United States during the past twenty years has not been an unqualified success, several of the new decolorizing carbons, after a brief period of use, having been abandoned. The refining industry, at least, has shown little inclination to forsake the long established use of bone charcoal for any of the proposed vegetable substitutes.

One of the most important reforms in raw cane sugar manufacture during the past twenty-five years has been the almost complete abandonment of the wasteful "hot room" system and the introduction of methods for producing high-grade raw sugar and final molasses in one operation. In the former process the molasses from each strike was boiled to string proof and then stored in tanks in a hot room for several weeks or months until crystallization was complete. The results were impure sugars of low polarization and inferior molasses, which during the long period of exposure in the hot room had undergone deterioration as a consequence of the so-called "froth fermentation" and also by the destructive action of *citromyces* and other micro-organisms. In the new process, as a result of improvements developed largely by the late Dr. G. L. Spencer at Tinguaro in Cuba, the molasses and massecuites are mingled in crystallizers where the mass is slowly cooled in motion, the material being afterward purged in centrifugals with the production of a high-grade raw sugar of 96 deg. or 97 deg. polarization and an exhausted molasses. In this way the excessive space requirement and tank equipment of the hot room, the inconvenience and excessive labor of repeated handling of products, the locking up of capital for long periods of time and the losses of the old system, due to the expenditures for heat, deterioration and other causes, have been entirely prevented.

The prophecy made by Doctor Spencer in 1910 that "within a few years the string sugars will almost cease to be produced" was quickly fulfilled. Molasses sugars made up over 8 per cent of the total sugars tested by the New York Sugar Trade Laboratory in 1909. This amount decreased to 1.85 per cent in 1913, dwindled to 1.13 per cent in 1918 and reached the final vanishing point of 0.19 per cent in 1924. This splendid result has meant a gain of many millions of dollars to the sugar industry of Cuba, which has profited to an almost equal extent through Spencer's efforts to produce a drier, cleaner sugar that would not deteriorate. These two accomplishments—the elimination of molasses sugars and the reduction of losses from deterioration—are lasting monuments to Doctor Spencer's work as a technologist.

In the utilization of the byproducts of cane sugar manufacture, two distinguishing accomplishments stand out during the past twenty-five years. The first of these is the production of the motor fuel "Natalite" (so-called from its having been first produced in Natal) which is made by the fermentation of sugar house molasses into alcohol. The latter, in order to be employed in the ordinary gasoline engine, requires to be enriched with a liquid fuel of lower volatilization point and ethyl ether, which can be manufactured directly from alcohol by treatment with sulphuric acid, has been found to be suitable for this purpose. The oxidation of alcohol to acetic and other acids will produce pitting or corrosion of the engine unless a slight amount of ammonia, pyridine or other organic base be added to neutralize the acid products of combustion. Natalite, as manufactured by various formulas, consists of

Ethyl alcohol (95 per cent), 54 to 60 per cent.
Ethyl ether, 45.8 to 39 per cent.
Ammonia, pyridine, trimethylamine, etc., 0.2 to 1 per cent.

A report upon the manufacture of industrial alcohol in Hawaii places the cost at 8 to 11c. per gallon, omitting the value of the molasses as a raw material. Each ton of raw sugar is accompanied by the production of about 42 gal. of molasses which will yield about 15 gal. of industrial alcohol. The Hawaiian alcohol motor fuel, based upon the formula of J. P. Foster, contains:

Ethyl alcohol (90 to 92 per cent), 75.2 per cent.
Ethyl ether, 22.6 per cent.
Kerosene, 1.5 per cent.
Pyridine or aniline, 0.7 per cent.

About 1.3 gal. of alcohol is required to make 1 gal. of ether.

Another important commercial byproduct of the cane sugar industry during recent years is the fiber board known as "Celotex" which is prepared from the bagasse of the cane mills. The utilization of sugar cane bagasse for the production of paper, fiber board and other cellular materials has been suggested for many decades, but none of the processes hitherto proposed has proved successful for the reason that the profits of the enterprise did not exceed the fuel value of the bagasse. This objection has been overcome in "Celotex" and now the sugar planter in favorably located sections can dispose of his bagasse at a price exceeding its monetary value as a fuel. The manufacture of "Celotex" have in fact contracted during the present season for the shipment of bagasse from Cuba to supply the needs of their factory in New Orleans.

In concluding this paper reference should be made to the improvements which have taken place during the past quarter century in the construction of tractors, ploughs, cultivators, hoists and other technical equipment for performing the agricultural operations of sugar plantations. In the final analysis the outlay for ploughing, planting, cultivating, fertilizing, harvesting and transporting the crop makes up over two-thirds of the total cost of a pound of sugar, thus leaving less than one-third for the expenses of manufacture.

Developments of Twenty-five Years in Coal Processing

By Horace C. Porter
Consulting Chemical Engineer
Philadelphia, Pa.

WE HAVE only recently begun to realize that coal is a raw material as well as a fuel. So far as America is concerned the development of coal processing, except by the coke oven method, has been begun and fostered within a period considerably less than twenty-five years.

We may go further and say that even the now highly developed and successful industry of byproduct coking has, in this country, only within the last twenty-five years been put upon a firm footing of sound engineering and commercial principles, leading to success. Previous to that time coal was looked upon very generally as a material only for the production of heat and power, one to be burned for what heat it could produce, in the easiest way, and with little or no regard for possible byproduct values. Twenty-five years ago, less than one per cent of the coal produced was made into byproduct coke, and about an equal amount was distilled for city gas. The byproducts obtained were almost a drug on the market. No other coal processing was even attempted.

At the present time byproduct coking and the gas industry with their use of 12 to 13 per cent of our coal supply and their annual sales of byproducts amounting to over $150,000,000 are exceedingly important exponents commercially of the processing of coal. No other phases, as far as commercial development is concerned, are yet in the same class.

The great accomplishment in these fields in the last twenty-five years has been the successful demonstration of the superiority of byproduct oven coke over beehive coke for metallurgical use, owing to its uniformity, reliability, and susceptibility to quality control in manufacture. In 1926, the pig iron industry of the country used 42,500,000 tons of coke and approximately 80 to 85 per cent of it was byproduct coke. Twenty-five years ago 5 per cent was byproduct coke; fourteen years ago 20 per cent. The total coke for all purposes produced in 1926 was 56,036,000 tons and 79.5 per cent was byproduct. These figures are ample evidence of the favor now accorded by iron makers to byproduct coke and of the almost complete reversal of their stand on this in twenty-five years. The byproduct coke industry deserves much credit for this accomplishment which it has brought about by systematic and scientific study of requirements and how to meet them.

Development of the byproduct coke industry offers a good illustration of the application of engineering and scientific studies to the lowering of costs and thus to commercial advancement. Capacity per unit of equipment has been greatly increased by the use of longer and higher and narrower ovens, and by better refractories and better construction. This, together with longer life of the ovens, has lowered the unit production cost and put the industry on a paying basis.

Another great advance in this field has been the improvement of coke quality by selection and suitable mixing of coals, and the demonstration that many Midwestern coals, if low in sulphur, may be used in the mixture along with the better coking coals and no serious detriment incurred to coke quality or byproducts. Coke ovens have proved also the excellent and dependable quality of their gas for public utility distribution. Well over half of all the coal gas distributed in city mains in 1925 was coke oven gas, or about 15 per cent of the total gas of all kinds publicly distributed.

For the gas industry, there should be recorded the steady and rapid growth during the last twenty-five years. The consumption increased from 85 billions of cubic feet in 1901 to 457 billions in 1916, a quintupling in a quarter century of an industry already seventy-five years old. Gas from the processing of coal has been a large factor in this growth, constituting now over one-quarter of all public utility gas.

These large commercial developments in gas and coke command great respect. But since their success has been firmly established for a number of years, a keener interest perhaps is aroused by some of the newer fields of coal processing. We are, therefore, giving space here in considerable measure to certain new developments, which have had the purpose mainly of converting coal into improved fuels for general use, both domestic and industrial, and securing oils and other basic materials for chemical manufacture.

This kind of "processing" is an endeavor to utilize rationally the values latent in the coal substance, including both those adapted to fuel purposes and those capable of chemical and manufacturing development. It has not yet secured a commercial foothold in this country sufficient to enable it to compete in any important degree in the general fuel field. But active development work has gone on, extending over a period of 15 to 20 years. Capital amounting to millions of dollars has been invested in plants and plant scale trials, some now abandoned, but others established and on a working basis that seems to promise for the future the reduction of costs to practical figures and the establishing of commercial operations on a profitable and successful basis.

SAMUEL WILSON PARR

Since 1891, Professor Parr has held the chair of chemistry at the University of Illinois. During that time he has been a leading authority on calorimetry and has devised a successful method of carbonizing Illinois and similar coals. His carbonization researches are now being developed commercially by the Urbana Coking Co.

CHARLES V. MC INTIRE

Long experience in the design and construction of by-product coke ovens has qualified Mr. McIntire to take a leading part in the development of low temperature carbonization. After seven years of painstaking engineering experiment, he has developed a successful continuous low temperature retort for the Consolidation Coal Products Co.

Photo by Blank-Stoller, Inc

WALTER RUNGE

Associated with low temperature carbonization work for many years, Dr. Runge has recently completed a large scale carbonizing plant based on earlier work by McEwen in England. This plant, which supplies powdered fuel to the Lakeside Power Station of Milwaukee, has operated continuously over long periods with an output of 200 tons per day.

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ARTHUR W. WARNER

Thorough theoretical and practical studies of low temperature carbonization by Mr. Warner has pointed the way to obtaining maximum utility value from the products of this process. He advocates the use of a retort that will permit the carbonizing to be carried out in zones, thus protecting the volatile products from undue heating.

Coal processing development has followed several lines:

1. As above explained, byproduct oven coking (at high temperatures), chiefly for production of metallurgical coke, with important side production of city gas, domestic fuel coke, tar, creosote, benzol, toluol, motor fuel and ammonia.

2. Retort gas making (at high temperatures) for the production of city gas, and, incidentally, fuel coke, tar and ammonia.

3. Low temperature carbonization, or the conversion of coal, by a moderate, slow heating, in absence of air, into a better grade fuel, together with oils or tar in important quantities and a rich gas. This line of development may be subdivided into:

   (a) Carbonization in mass, as in retorts or ovens, to make a stoker or domestic fuel, and by-products.

   (b) Carbonization as an adjunct to producer-gas manufacture.

   (c) Carbonization of powdered coal to improve its boiler-firing efficiency and secure byproducts.

   (d) Carbonization of coal in successive stages, low temperature to high temperature for securing both gas and coke in highest over-all yields and utility values; in other words, attempts to devise methods of carbonizing which will raise the percentage recovery of utilizable energy and material.

4. Mechanical processing, by briquetting or other such means, coupled sometimes with carbonizing.

5. Conversion of coal, through chemical action of hydrogen, or other similar treatment, into liquid fuels or chemical raw materials.

Notwithstanding these many lines of endeavor, to which careful engineering study and a large amount of capital expenditure has been devoted, the only developments that have resulted in active commercial success are byproduct coking and gas making. Briquetting has made a certain amount of commercial progress. But in all summaries of industrial progress—and *Chemical and Metallurgical Engineering* is to be commended for this broad viewpoint—pioneer work in a large and promising field deserves recognition, even though still struggling against odds commercially.

To make out of bituminous coal—which itself is often objectionable for many uses and of a low order of utility value—a clean, smokeless, efficient domestic and industrial fuel and recover byproducts meeting a real demand, is a goal well worth striving for, and one which, attained, will have far-reaching effect upon industrial progress.

The aim has been, in America, not principally to provide oils or motor fuel to supplement petroleum, or to furnish to the gas industry a means of enrichment or other auxiliary or supplementary agency, but rather to improve bituminous coal, and particularly certain types of coal, as the Midwestern with relatively high oxygen content, to fit them better for domestic and power-plant fuels. The byproducts of gas and oils are useful as a means of paying the costs, but not, so far as this country is concerned, the main consideration.

The costs of processing include not only the plant and the labor and materials, but a considerable outlay of the energy store in the coal itself. Accordingly the task of developing an economically successful coal processing method is a difficult one. By simplicity and reliability in operation it must keep costs at a low level and at the same time furnish products whose enhanced efficiency and marketability will more than counterbalance the unavoidable loss of gross original energy in the coal. The margin that this enhanced unit value in products furnishes over costs of conversion must be such as to create a real incentive for the undertaking. It must

also be such that fuel efficiency gained in the use of the products will counterbalance the fuel consumed or lost in the course of the processing, so that in the end conservation of resources will be maintained.

Among the foremost of those who have pioneered in these lines with conspicuous and valuable service stands Prof. S. W. Parr of the University of Illinois. How to "process" Illinois coals, and others like them, to the best advantage has been a major study with him and his associates for twenty-five years or longer. Parr's process, for development of which commercially the Urbana Coking Company has now been organized and a plant is being built, succeeds in making strong, blocky, highly combustible coke out of many grades of Illinois coal.

The Parr method, devised as a result of careful scientific studies, uses two stages of heating, in the first of which the coal, with agitation, is moderately heated, enough to drive off its moisture and some combined water and carbon dioxide, altering thus in some degree the chemical character of the substance. In the second stage then, transferred to a vertical retort at 1,200-1,250 deg. F. the coal, already heated through and deprived of its disturbing oxygenated compounds, allows a rapid rate of coking throughout its mass and a better coke formation. Exothermic reactions in the coking mass probably contribute to this rapid penetration of heat into the interior of the charge.

By this method of getting a good strong coke from the Illinois type of coal at moderate retort temperatures and yet at practical retorting rates, Parr is able to avoid the destructive breaking down of valuable oils and by-products that occurs in the high temperature processes, to secure thus high yields of tars, and to make a coke that by reason of its higher degree of combustibility is more generally useful.

Among others who have pioneered in this field and to whom especial credit is due for advancement of the art, mention should be made of Charles V. McIntire, Engineer, of the Consolidation Coal Products Company, Fairmont, W. V., who has brought about valuable improvements in the important mechanical engineering features of coal processing. Working on the Pittsburgh coal, one of the most difficult to handle in any continuous process of carbonizing, McIntire has succeeded in developing a continuous low-temperature retort, which mechanically has demonstrated successful and continuous operation on a scale of 50 tons per day over long periods. Commercial development is now pending.

WALTER RUNGE, consulting Chemical Engineer, of New York, basing his researches on earlier work of McEwen in England, has made important progress is devising methods of carbonizing or processing powdered coal industrially. A plant of commercial size has been built at the Lakeside Power Station, Milwaukee, Wis., and operated continuously during long periods at a rate of over 200 tons of coal per day. Runge does not claim, however, that his process is as yet firmly established on a commercial basis. This pre-carbonizing of powdered coal is designed to improve the efficiency-capacity ratio in firing powdered fuel under boilers and at the same time secure valuable byproducts in tars and rich gas. Dr. Runge's name has been prominently identified with developments in coal processing by low temperature carbonization for a number of years.

For thorough studies, theoretical and practical, of the processing of coal by carbonization, with a view to its rational heat treatment and the securing of maximum aggregate utility value in the products, the name of Arthur W. Warner, gas engineer, of Chester, Pa., stands out prominently in the developments of recent years. Mr. Warner was awarded the Beal Medal of the American Gas Association in 1923 for his achievements.

WARNER advocates essentially a design of carbonizing mechanism, operated in steps from low temperatures to high, and which will withdraw the volatilized products in a direction away from the source of heat, thus keeping them away from very hot surfaces and avoiding intensive degradation into products like carbon or pitch of lesser utility value. Theoretically he gains in this way greater utilizable values in gas and in solid residue, with maximum yield also of oils. He is at this time working upon the development of an industrial gas retort along these lines.

Other developments to be noted in coal processing in America are:

The Carbocite Process, Canton, Ohio, whereby, in two successive horizontal rotating retorts, coal is rolled up or sintered into "balls" of semi-carbonized material. A trial plant, now nearing completion, has been installed on a commercial scale at the Philo, Ohio, power station of the American Gas and Electric Co.

The Greene-Laucks continuous carbonizing process which is under development industrially by the Old Ben Coal Corporation, Chicago.

The "Navicoal" process, for which a commercial plant has been built and is in operation at Perth Amboy, N. J., by a subsidiary of the Lehigh Coal and Navigation Company, which briquets a mixture of fine anthracite with bituminous coal and carbonizes the briquets;

The Trent Process of carbonizing an "amalgam" of finely ground coal and oil, for which trial plants are under development;

The Hood-Odell carbonizer for lignite, developed by the Federal Bureau of Mines, for industrial preparation of an improved fuel out of the Western lignites, wherein lie vast possibilities of future development following industrial growth of the territory.

A new type of coal processing now being developed abroad, and attracting attention also in this country, is the liquefaction of coal by the action of hydrogen gas under pressure. Space is lacking here to describe the Bergius process, which treats coal directly in an autoclave with hydrogen at 3,000 lb. pressure and about 900 deg. F. obtaining a 50 per cent yield of oil, or those of Fischer of Germany or Uatart of France, which convert carbon-monoxide gas, made from coal, into liquid fuels or methyl alcohol.

These are very recent and striking developments in the coal processing field and augur much for the future, when there may well be economic conditions such as to promote their development. With the abundant present resources of America in coal and oil these liquefaction processes are not likely to gain commercial headway here at an early date. It is significant, however, that the processes are especially well adapted for use in treating lignites and other coals of our Western territory, and when the time is ripe their application may be found in the development of that field.

Twenty-five Years of the American Dye Industry

By C. G. Derick
Derick Laboratories, Inc., Chesterton, Ind.

"WITHOUT intention to minimize what has been done before 1882, this analysis (of records of tariff hearings) will show that a real conscious, self-contained industry, dates from then on—that there has been a steady progress for the American dyestuff industry from then until the outbreak of the European War. The logic of events, had there been no European War, would have led to the elimination of existing obstacles and the ultimate creation of a satisfying, self-contained American dyestuff industry. The development in that case would have been in a better sense of proportion, more harmonious, more in line with sound economic maxims, and less hysterical and passionate than under the jerk of a world catastrophe." This pronouncement in 1924 by such an eminent authority and pioneer in the American dye industry, George A. Prochazka, merits serious attention and careful analysis as it appears to challenge much that has been discussed and published since the "jerk" of the 1914 catastrophe.

The last twenty-five years of the American dye industry is divided into two significant periods by the outbreak of the World War. The first period from 1900 to 1914, was of exceptional importance. At its very outset (1901), the Schoellkopf, Hartford & Hanna Co. of Buffalo obtained patents for the successful processes for the manufacture of direct blacks (Schultz 462 and 463). These products were first patented by Dr. O. Muller, but it remained for the scientists, Drs. Richard Taggesell, Rempacker and E. Culmann, under the executive leadership of J. F. and Hugo Schoellkopf, of the Buffalo firm, to develop the commercially successful Erie direct blacks, the most important, financially, of all the direct dyes. This accomplishment was a magnificent proof to the world of the existence of this "real conscious, self-contained industry" in America, proclaimed nearly fifty years ago by experts like George A. Prochazka.

Of great significance to the expansion of the American dye industry during the War was the fact that during this period from 1900 to 1914 a group of younger scientists was being trained in the art of dye and intermediate manufacture at the Buffalo concern in particular. Their accumulated experience had already resulted in the permanent manufacture of the list of Buffalo products mentioned by Norton in his dyestuff census for the fiscal year 1914. Thus Dr. W. J. Stanton was manufacturing chrome and acid colors; Dr. Edward Ruppert, fuchsine and alkali blues; A. S. Holland, oil colors and Dr. J. F. Schoellkopf, Jr., nigrosines.

One notable American Buffalo concern played an important role, was certified development in which the colors. This work at Buffalo was carried out by Willard H. Watkins and Alfred Holland. The Kohnstamm concern were also pioneers in the production of certified colors.

The name of Heller & Merz as producers of dyes for the paper industry was firmly established. Just prior to the War the W. Beckers Aniline & Chemical Works, Inc., were establishing themselves, specializing in alizarin substitutes.

It has been generally stated that the American dye industry, previous to the War simply assembled foreign intermediates into dyes. Just previous to 1884, the Buffalo firm "were producing coal-tar distillates, aniline oil and a few important dyes. Research work had also progressed to the stage that permitted them to patent several processes for the manufacture of important intermediates and dyes. The process for one of these intermediates was the foundation for the development of a considerable number of very important dyes brought out in Germany. The Schoellkopf works, however, drew royalties on the utilization of their patented processes," says Willard H. Watkins. The tariff revision of 1884 did away with the specific duty on coal-tar dyes and made radical changes in policies, causing this and all other American companies, for the most part, to cease the manufacture of intermediates, in favor of German imported products. Dr. Watkins says further, "At all times, however, the officers of the Company (Schoellkopf) were alive to the importance of carrying on their own manufacture of these products. The manufacture of no intermediate that could be produced at anything approaching the cost of importation was ever discontinued. Some few important intermediates were always made by this Company such as sulphanilic and metanilic acids, toluidine sulphonic acid, naphthionic acid and Neville & Winther's acid. Other important intermediates, such as H-acid had been made but necessarily discontinued. Others had been studied from the chemical side. *A corps of capable chemists considerably larger than ordinary operation demanded, was always maintained.*"

The year 1910 saw the birth of a successful attack upon the foreign monopoly in basic intermediates more closely related to the coal-tar distillates, which meant gradually complete economic freedom for the American dye industry from crudes to finished dyes and fine organic chemicals. Economic conditions had so changed by this date that the manufacture of aniline (nitrobenzol) was

begun jointly by the General Chemical Co., The Semet-Solvay Co. and the Barrett Co. at the latter's plant at Frankford, Pa. A. B. Mitchell was brought over from England to operate the plant, having had experience in the Barnes plant in England. He was assisted by A. G. Peterkin, Jr.

The year 1913 saw a production of 2,000,000 lb. But domestic demands caused the immediate erection of the plant of Benzol Products Co. at Marcus Hook, Pa., under the supervision of A. B. Mitchell and F. W. Barker, Jr., who operated during the War, together with H. B. Bishop and others. It was a short step to nitrotoluols, toluidines, xylidines, aromatic diamines, etc., once the manufacture of aniline was firmly established. The manufacture of aromatic amines upon a sound economic basis was one of the most important pre-war accomplishments and fittingly closed this tremendously productive period of the American dye industry, 1900 until the outbreak of the World War in 1914.

But now to the "hysterical and passionate" period "under the jerk of a world catastrophe." This second period from the outbreak of the War to date was peculiarly the period in which intermediates and crudes were developed and manufactured in America. It is outstandingly the period of chemical engineering development. On the chemical side it was largely a problem of expanding the scientific personnel experienced in the art of dye making. Raw technically trained recruits were hastily assembled. If experienced leadership was available, conservative progress resulted with relatively small financial waste. If no experienced leadership was available, the losses of single firms ran into the millions. But what a glorious time the chemists and engineers had while the money lasted! America will always be the richer for having had the opportunity to spend in the dye industry without counting the cost at the moment.

Of first importance during this period was the immediate establishment of comprehensive research organizations as that of the Barrett Co. led by J. M. Weiss; of the Semet-Solvay Co. by Dr. L. C. Jones; of the du Pont company by C. L. Reese; of the Newport company by Dr. I. Gublemann; of the Color Laboratory, Department of Agriculture by H. D. Gibbs and of the Schoellkopf company by C. G. Derick. These research departments were the organized training schools for the expanding technical personnel and their products in terms of human scientific brains offset the terrible mauling the industry received during recent years at the hands of certain financial interests.

The disintegration of nearly all of these comprehensive research organizations is the most severe blow that recent years has dealt this industry. Today we are again largely a "nation of leaners" as far as this industry is concerned, to use the expression of Farrell.

The manufacture of aromatic nitro compounds and amines so ably established by the Benzol Products Co. during the first period, was madly duplicated by many in the second period, with the resulting waste of enormous amounts of capital, and the only benefit accruing to the technical staffs and the manufacturer of equipment. What is true of these bulk basic intermediates, was true on a smaller scale for nearly every intermediate. A single plant was erected with capacity to manufacture the world demands for beta naphthol, but this was not enough, it was duplicated at dozens of points in this United States. The familiar financial crashes in the industry during recent years were inevitable. But if this situation was true for the intermediates where some hesitation was forced upon one due to the large investment demanded in equipment, no such deterent existed in the case of the dyes. The single company at Buffalo made nearly seventy-five per cent of the consumption of this country and Canada, in the early part of the period and had capacity to make the entire normal

J. F. SCHOELLKOPF

J. F. Schoellkopf will always be a prominent figure in the history of the American dyestuff industry. He was a member of Schoellkopf, Hartford & Hanna Co., which was organized in 1901 and which obtained patents on processes for the manufacture of direct blacks known as Schultz 462 and 463, first invented by Dr. O. Muller.

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HUGO C. P. SCHOELLKOPF

Hugo C. P. Schoellkopf, with J. F. Schoellkopf and others constituted the executive staff of the Schoellkopf, Hartford & Hanna Co. Under the executive direction of the Schoellkopfs, Drs. Richard Taggesell, Rempacker and Edward Culmann developed the Erie direct blacks, which financially proved to be the most important of the direct dyes.

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EDWARD CULMANN

In 1900 Dr. Culmann became associated with the Schoellkopf, Hartford and Hanna Co., where he remained until 1920, when the company was reorganized as the National Aniline & Chemical Co. He then became technical director of the Lock Haven plant of the American Aniline Products, Inc., which position he held at the time of his death in June, 1926, at the age of fifty-six.

WILLARD H. WATKINS

A notable development in the American dyestuff industry was the production of certified colors by the Schoellkopf, Hartford & Hanna Co. of Buffalo, N. Y. In this and other developments of importance during the period from 1901 to 1914, Willard H. Watkins played an important part. Until recently he was with the National Aniline company.

Alman & Co.

demands of this country in most lines. The high mortality of dyestuff companies since 1918 is a cruel witness to the situation. However, results of lasting value are inevitable from such an opportunity, no matter how badly it is handled.

The emergency demands of the War for toluol soon solved the question of a permanent supply of these lighter coal-tar crudes, as byproduct coke ovens began rapidly increasing and the automotive industry to absorb almost limitless quantities of surplus. The domestic demands had already assured the permanent supply of naphthalene and phenol. Anthracene presented a much more difficult problem and one that is not necessarily settled at this writing. The demand for anthracene has temporarily ceased, due to the synthesis of anthraquinone from phthalic anhydride and benzol.

One of the outstanding accomplishments of this period was the catalytic synthesis of phthalic anhydride by Gibbs and his associates of the Color Laboratory at Washington. No one could foresee the present enormous production of this intermediate nor its present price, relatively below that of the pre-war days. It made possible American vat dyes and synthetic solvents and plasticizers for the lacquer and synthetic resin industries. Its influence upon the method of manufacture of indigo is hidden in the future. It is peculiarly fitting that it should be the result of research sponsored by our federal government.

The Benzol Products Co. early in this period expanded its production to include that of ortho and para nitrotoluol and the corresponding toluidines and similar products. Simultaneous development in these lines occurred at the Atlantic Dyestuff Corporation under the leadership of J. Nachsatz and O. Smith, at the Newport Chemical Works, Inc., under Dr. A. J. Weiland, W. V. Wirth, P. Hand and C. N. Davidson, and at the du Pont company. Many other nitro aromatic derivatives and amines were developed by the same organizations.

CHLORBENZOL as a starting point for the manufacture of intermediates and dyes was early recognized as possessing peculiar advantages to the American dye industry. The development of the processes for the manufacture of this very important basic intermediate was early accomplished by the Niagara Alkali Co. and by the Hooker Electrochemical Co.

The unexpected result that the original waste dichlorbenzol had many commercial uses as a spray and deodorant, illustrates one of the unexpected economic changes in this field and is occurring with such frequency in the American dye industry as to completely upset pre-war production and prices in such lines.

Using the basic intermediate, chlorbenzol, as the starting point, the Schoellkopf concern developed the manufacturing processes for ortho nitroanisol, ortho and para anisidin, and dianisidine, under the leadership of C. G. Derick, D. W. Bissell, R. A. Nelson and others.

Accordingly, the development by the Barrett Co. of nitro naphthalene and alpha naphthylamine under the leadership of A. G. Peterkin, Jr., S. P. Miller, W. B. Murphy and their assistants was a welcome aid to the expanding industry. This development was soon duplicated by the Newport Chemical Works, Inc., and others.

Early in 1915 some dye concerns were manufacturing their own beta naphthol and others rapidly took up its manufacture. With the appearance of the production of Calco Chemical Co. and its insistance upon the sound economic policy that certain intermediates could be manufactured at one plant in bulk much cheaper than by dozen small competitors, the wiser and experienced dye manufacturers ceased the manufacture of beta naphthol.

The Dow Chemical Co., under the leadership of Herbert H. Dow, one of America's foremost chemical pioneers, attacked the problem of indigo. Indigo is used to the greatest extent of any single dye in America. January, 1917, witnessed the first sales of this production and ever since, Dow indigo has maintained a prominent position in the world market. For during this year production was started by National Aniline & Chemical Co., Inc., and E. I. du Pont de Nemours & Co. and competition has been so keen that today indigo is selling at a price relatively lower than at any time in the history of the dye industry. About this product is woven the demonstration that United States can hold its own in world competition in the dye industry, in certain lines at least.

ANOTHER gap in the complete line of American dyes was the sulphur colors. Early in 1916, under the leadership of Dr. J. F. Schoellkopf, Jr., the Buffalo concern put into operation a modern plant for the production of sulphur black, the second most extensively used dye in America. By the end of 1917, twenty-one firms were reported as manufacturing this single dye. The product of Atlantic Dyestuffs Co., produced under the leadership of G. Rackely, held a prominent position in the early part of the period.

Alizarin was produced by National Aniline early in 1918 under the direction of the late E. G. Griffin. The process was developed by the Barrett research staff and much credit is due J. M. Weiss and Dr. C. R. Downs. Progress has been made in the field of alizarines by the above concern and Beaver Chemical Corporation, yet much remains to be done to complete this phase of the American dye industry.

One of the last branches of the American dye industry to be developed was the vat dyes. Experimental manufacture of important dyes of this group had occurred in 1918 by certain firms, some of whom hesitated to start regular production despite the fact that this was the latest field of world dye development thus offering the greatest chances of discovery and patent monopoly. Little did these concerns realize that new trade demands just a few years ahead would rapidly increase the demands for these dyes and that today their importance would be many times greater than in 1914. This lack of foresight and belief in productive research marks a turning point in the relative importance of certain dye concerns in America. The du Pont company under the able scientific leadership of Drs. Stine and Bolton and their associates, during the last few years has steadily increased in importance with its well known appreciation of the relation of research to industry, although it did not enjoy the years of pre-war experience that was the heritage of certain other concerns. To this company and the Newport Chemical Co. under the leadership of W. M. Murch and M. T. Coakley, is due the main credit for supplying America with a domestic production of vat dyes. The work is still incomplete.

Twenty-five Years' Progress in High Explosives

By Charles L. Reese
E. I. du Pont de Nemours & Co., Inc.
Wilmington, Del.

TO PRESENT an adequate account of the chemical and chemical engineering developments that have occurred in the explosives industry since 1902 is perhaps beyond the ability of a single individual. Certainly it is a story that cannot be confined within the limitations of a brief article; in fact, volumes have already been written to record the accomplishments of the explosives industry during this momentous period in world history. The Institute of the Makers of Explosives of the United States now has in the final stages of preparation a comprehensive history of the commercial development of the explosives industry in America. Rather than to touch upon this phase of the industry's development it will be the purpose of the present article to summarize in a very general way some of the more important results of the work which has been done at the Eastern Laboratory of the du Pont company, which was established just twenty-five years ago and has confined itself primarily to research on subjects connected with the manufacture of high explosives. Furthermore the information as presented here is largely an adaptation by the editors of this magazine of historical material from an address on this subject which the author delivered before the Franklin Institute on the occasion of the observance of the centenary of its founding.

In 1923 the records of the Bureau of Explosives show that 530,000,000 lb. of explosives were produced and distributed in this country of which 330,000,000 lb. were high explosives. This would mean that about 100,000,000 lb. of nitroglycerine were produced or 50,000 tons. With an enormous production such as this, the question of yields, based on glycerine and nitric acid use becomes an important one.

Since the nitration takes place readily under conditions which prevent oxidation, that is at relatively low temperatures, the yields should be practically theoretical on the pure glycerine used were it not for the solubility of the ester in the waste acid and in the wash waters used in the process.

Nitroglycerine yields are stated in the art as so many pounds per 100 lb. of glycerine, and in the nineties a yield of 215 to 220, 88.9 per cent to 91.1 per cent based on 98 per cent glycerine was considered very good. An increase of about five points was brought about by Lawrence, who lowered the solubility in waste acid by cooling the latter, after separation, down below the freezing point of nitroglycerine.

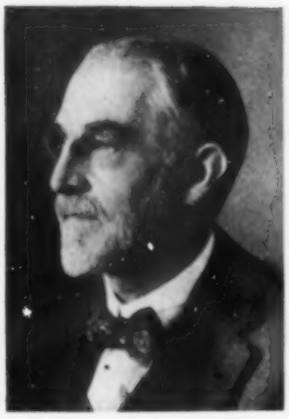
With the advent of fuming sulphuric acid in 1901, it seemed likely that its use would bring about much improvement in the manufacture of nitroglycerine. However, owing to the extreme and proper conservatism of manufacturers of this dangerous material, it took much time and experiment, both in the laboratory and on a semi-works scale, to determine the best and safest ratio of nitric acid, sulphuric acid and glycerine, and, what is very important, the best ratio of sulphuric acid to water in the mixture, plus the water of reaction to bring about such improvements as are represented by yields of 233 to 235 with much reduced consumption of nitric acid. The higher yields are largely due to reduction in the ratio of waste acid to nitroglycerine and the higher acidity of the former, rendering the nitroglycerine less soluble.

Such yields with 98 per cent glycerine are 96.4 per cent to 97.2 per cent of the theoretical and when we consider the solubility of nitroglycerine in waste acid and wash waters, they are practically theoretical. Still higher yields can be obtained with higher consumption of nitric acid but this is controlled by the relative cost of the two ingredients. Eleven points in yield mean a saving to the industry and to the customer as well of $750,000 to $1,000,000 per year.

The freezing point of nitroglycerine for many years was held to be about 12.8 deg. C. (55 deg. F.) but in 1906 Kast announced the discovery of an isomeric form of solid nitroglycerine melting at 2.8 deg. In 1911 Nauckhoff attempted to produce this lower freezing form but failed.

The obvious method of reducing freezing point is to dissolve some substance in the liquid, and in our search for such a substance nitro bodies with some explosive potential naturally suggested themselves. The liquid isomers of 2.4.6, trinitrotoluene, a byproduct of the manufacture of that body, proved to be very useful in reducing the freezing point of nitroglycerine and a class of low-freezing dynamites and ammonia dynamites were manufactured and introduced about 1907. Although many million pounds of low-freezing powders which contained these mixtures and which were satisfactory to the trade were sold and used, they were not entirely satisfactory on account of odor and staining of the cartridge wrappers, so that after the manufacture of trinitrotoluene had been established, and cost reduced sufficiently by tonnage manufacture, it was decided to use this explosive in the place of the former mixture since it gave more satisfactory results.

This was also more satisfactory because of its higher potential strength. The use of this material in low-



ARTHUR MESSINGER COMEY

Dr. Comey was a consulting chemist in Boston from 1893 until 1906 when he entered the employ of the duPont company and was appointed director of its Eastern Laboratory. Then followed 14 years of intensive work on high explosives which included the discovery of a practical method of utilizing nitrated sugar in dynamite.

FLETCHER B. HOLMES

Entering employ of the du Pont company in 1903 as a research chemist, Mr. Holmes was later assistant director of Eastern Laboratory in charge of work on the development of high explosives, particularly nitrostarch. Since June 1917 he has been Director of Jackson laboratory handling development work on dyes.

CHARLES M. A. STINE

Dr. Reese's successor in 1924 as chemical director of the duPont company made his first connection at the Eastern Laboratory in 1907 specializing in ammonium nitrate, permissible explosives, trinitrotoluene, picric acid and nitro aromatic compounds in general. Dr. Stine was from 1919 to 1922, in charge of research on dyes.

HAMILTON BRADSHAW

After receiving his doctor's degree from Johns Hopkins in 1905, the present assistant chemical director of the du Pont company entered the Eastern Laboratory and was identified with explosives investigations there for 7 years. From 1913 to 1920, Dr. Bradshaw served as assistant director and director of the Experimental station.

Wm. Showell Ellis

freezing explosives continued up to the beginning of the World War, when it became necessary to conserve all toluol for military purposes.

In 1911 nitrated mixtures of glycerine and sugar mixed with T.N.T. (Woodbury, U. S. Patent 1,149,487) were introduced. Although the calculated freezing point of this new liquid mixture was not much lower than the one previously used, dynamite containing the same showed a very marked resistance to freezing even at temperatures below 0 deg. F. These explosives had been used very extensively throughout this country but as far as I know had never been introduced in Europe up to that time.

The methods of producing low-freezing dynamite which I have already referred to were never applied to so-called safety or permissible explosives, nor to gelatine dynamites. The first low-freezing dynamites of these classes were developed during the years 1911 and 1912 as a result of a long study on the condensation or polymerization of glycerine and nitration of the polymers. The method for condensation of glycerine worked out in our laboratory by S. H. Fleming (U. S. Patent 978,-443, 1910) consists of heating dynamite glycerine to about 230 deg. C. to 250 deg. C. in the presence of ½ per cent to 1 per cent of sodium acetate under a partial vacuum of 150 to 250 mm. of mercury. In this way 70 per cent to 80 per cent of the glycerine is condensed to di-glycerine in less than one hour.

Many disastrous explosions and much loss of human life have occurred in gaseous and dusty coal mines which resulted early in the nineteenth century in the invention by Sir Humphry Davy of his safety lamp which proved to be such a boon to the miners of coal.

There was little hope of overcoming the danger due to the use of explosives in such mines as long as black powder was the only available one to be used. Many mechanical and chemical devices were invented to take the place of explosives but none was satisfactory. In 1885 the German government took the matter in hand and research has been carried on not only there but in England, France, Belgium and other countries ever since, to produce explosives safe for use in coal and other mines.

It was my privilege, when the Eastern Laboratory of the du Pont company was established in 1902, to be able to attack this problem, as there had been nothing done up to that time to develop such satisfactory explosives in the United States, except for the sale of a few lots of so-called "flameless powders" built on some early but unsatisfactory formulas, depending upon the use of ammonia sulphate and alum in rather large proportions—the water of crystallization in the latter being supposed to keep the temperature of combustion down as low as possible.

All possible information was secured from Germany and other European countries, and particularly the apparatus developed by Bichel, Schmidt and Mettegang, including the pressure gage, calorimeter, apparatus for velocity of detonation and for photographing and measuring the length and duration of flames all of which were installed in 1904. With this equipment installed we were pioneers in attacking this highly important humanitarian problem in this country. In order to get such explosives in the hands of miners, we selected out of thirty odd formulas, the best powder which had been developed in Europe at that time as established by our own studies, namely, the German carbonites and the English monobels.

The carbonites and monobels were put on the permissible list as soon as they could be tested at Pittsburgh prior to March, 1909. The safety of the carbonite class is dependent upon their high carbon and moisture content in comparison with their oxygen content and consequent low temperature of explosion. The safety of the monobel class is due largely to their high ammonium nitrate content and consequent low temperature of combustion.

Realizing that the annual increase in the use of high explosives in which nitroglycerine was the principal explosive ingredient and that glycerine is a byproduct of the soap and candle industry, it was felt that sooner or later there would be world shortage of this material and our attention was directed at the inception of our laboratories, to the question of substitutes for nitroglycerine.

AS EARLY as 1885, through the efforts of R. S. Penniman and J. C. Shroeder, ammonium nitrate was used to some extent as a partial substitute for nitroglycerine in so-called straight and gelatine dynamite to the extent of about 10 lb. of nitrate of ammonia for 7 lb. of nitroglycerine, but on account of its hydroscopic properties it was found necessary to protect it from atmospheric moisture by coating it with petrolatum by a process invented by Penniman in the same year.

This substitution gradually reduced the average amount of glycerine used in dynamite from 40 per cent to 30 per cent.

Although earlier attempts had been made to utilize nitrated sugar in dynamite, Dr. A. M. Comey of our Eastern Laboratory discovered that if refined glucose or cane sugar were dissolved in glycerine, the mixture could be readily nitrated under the refrigeration process at that time in general use, but a special process was necessary to purify the nitrated mixture, and after several years work it was found possible to utilize a mixture of 80 per cent of glycerine, and 20 per cent of sugar in all cases of explosives, and by this means 20 per cent of the glycerine was substituted.

Many attempts were made, about 1900 and later to manufacture a stable nitrated starch, and many samples which were claimed to be stable were secured which disappeared after storage through fire due to spontaneous combustion. This problem was attacked early in our work and was satisfactorily solved early in 1904 by the discovery that when ammonium oxalate is mixed with the explosive in very small proportions, say from 0.5 per cent to 5 per cent, either dry or wet, a satisfactory stable nitrostarch could be produced (U. S. Patent 891,-420 to Dr. F. B. Holmes), and it was afterward found that many other ammonium salts, both organic and inorganic, produced similar effects as well as such substances as oxamid and aniline oxalate, all of which have been covered by U. S. patents.

After a visit to Europe in 1908 when I saw two large plants in Germany for the manufacture of trinitrotoluene, I became convinced that this material would become of great importance in the future, and on my return immediately started work on a process for its manufacture, and, after much laboratory investigation, a small plant was built and operated successfully in the spring of 1910.

The product of this plant was used in low freezing dynamite, as I have mentioned before. In 1910 I was in a position to bring this explosive to the attention of the Army and Navy and succeeded in interesting the Chief of the Coast Defense, and after some experimenting on material we were able to furnish, it was adopted for submarine mines by that department.

The first large plant for the manufacture of this important explosive was built to fill an order for 500,000 lb. to be delivered in one year for submarine mines; and thus this country was provided with knowledge and experience to meet the exigencies of the World War in the production of this exceedingly useful explosive.

It occurred to me, however, that we should be able to make trinitroxylene on a large scale and utilize it in connection with trinitrotoluene. Trinitroxylene is not suitable alone for shell and other bursting charges on account of the high melting point (182 deg. C.) and consequent difficulty of loading, the melting point of trinitrotoluene being 80.6 deg., well below the boiling point of water. It was at first thought that a eutectic mixture could be made of these substances which would melt low enough to be cast, but it was found that this was not the case as the xylene body was very slightly soluble in the toluene body. However, it was found that a mixture of 40 per cent trinitroxylene and 60 per cent trinitrotoluene could be brought into a sufficiently fluid state at temperatures below the boiling point of water to enable it to be readily cast into shells, (U. S. Patent 1,309,588, July 8, 1919, to C. L. Reese) and form a compact filling without the attendant difficulties that were met with in loading that heavy important mixture of ammonium nitrate and trinitrotoluene known as "Amatol" which was developed in England during the war.

Our first work on this explosive was done in 1913, but was abandoned on account of the press of other work, but in the summer of 1917 it was taken up again. The laboratory work and the development of the manufacturing process consumed more than a year and a half, and as a result a plant was constructed for the production of 30,000,000 lb. of T.N.X., to fill an order for the U. S. Navy. Two of the five units of the plant were completed and in satisfactory operation at the time of the armistice, with the other units nearing completion or in partial operation. (For more details see article by John Marshall, entitled "The Manufacture of Trinitroxylene for Use as a Substitute for T.N.T. in Bursting Charges for High Explosive Shells," *J. Ind. Eng. Chem.*, Vol. 12, No. 3, p. 248, March, 1920.)

TO REVERT to the question of nitroglycerine substitutes, many attempts have been made to find such a material without success up to the present, but it might be of interest to mention some of those which have been proposed.

It is true that glycerine has been synthesized although not economically. It has also been produced by fermentation in Germany, under the stress of the necessities of war, from beet sugar, but this raw material is too expensive for its normal commercial production. This is a problem on which we have been working for many years, starting, however, from a much cheaper source of sugar, namely, molasses. The use of this raw material introduced complications due to the impurities in the molasses, but a process has been developed to overcome these difficulties and I feel that I can safely predict that after some chemical engineering difficulties met with in large-scale production, have been overcome, this process will be put into practical operation.

In concluding, I wish to state that I have been unable to touch upon many important developments in smokeless powder, or improvements in acid manufacture or solvent recovery. Our efforts have been to advance the art to reduce the danger, not only in the manufacture, but also in the handling, transportation and use of a material intended to work by explosion, and thus reduce accidents to humanity to the minimum.

Paint and Varnish Developments Since 1902

A reminiscent interview with

R. S. Perry

Consulting Chemical Engineer, New York City

EVERY story must have its beginning and when Mr. Perry was asked to suggest the approximate date at which chemical engineering had its first real influence on paint and varnish technology, he set that date in the neighborhood of 1906. Of course, even before that time there were chemists who were active in the industry and were making some technical progress, particularly in the direction of chemical control. The A.S.T.M. Committee E on preservative coatings for iron and steel was one of the first activities of that society which had been founded in 1898, and by 1902 its membership had included such eminent paint chemists as Dr. G. W. Thompson of the National Lead Co., Professor A. H. Sabin, then with the Edward Smith Varnish Works, the late Charles B. Dudley, chief chemist, Pennsylvania Railroad. On the A.S.T.M. membership list for 1906, however, you will find the names of Maximilian Toch, chemist and manufacturer, E. C. Holton, chemist for Sherwin-Williams Co., Frank P. Ingalls, chemist for John W. Masury Co., A. H. Hooker, chemist for Heath & Milligan, D. A. Kohr, chemist for Lowe Bros., Dayton, and R. S. Perry, then president of Harrison Brothers & Co., of Philadelphia. Doubtless there were a number of others who are no longer identified with the paint and varnish industries.

But to get back to 1906: It was about that time that the late United States Senator Edwin F. Ladd, serving as Pure Food & Drug Commissioner for the State of North Dakota, came prominently to the attention of the paint and varnish industry in connection with the so-called "pure paint law" of that state. This law, which made it necessary to label all mixed paints except those of certain compositions, was aimed to do away with many worthless mixtures that were then parading under the name of paint. These dope paints, containing all forms of adulterants, were being foisted on the public by mail-order houses and fly-by-night manufacturers who were looking for a temporary profit. Their nefarious practices were tending to discredit the entire paint and varnish industry and the legitimate manufacturers of high-grade mixed paints immediately felt it necessary to set their house in order by weeding out the quacks and by definitely establishing and proving the scientific basis for their manufacturing practices.

The master painters and the architects were then, as now, important factors in the situation. At a meeting of some of the leading master painters held in 1906 at Atlantic City, with a small group of paint and varnish manufacturers it was desired that a chemical study of all mixed paints should be made, particularly as to the role played by accessory pigments that improve the qualities of paint by reinforcing the properties of the major constituents.

Although the first U. S. patent (66,773) on a prepared paint had been issued July 16, 1867, to D. Averhill of Newburg, Ohio, mixed paints were still in disfavor with the architects. Accordingly, a program of educational work was inaugurated and in Detroit on June 4, 1907, a meeting was held with the American Institute of Architects.

This educational movement culminated in the formation within the same year (1907) of the Educational Bureau of the Paint and Varnish Manufacturers' Association, and inaugurated the Scientific Section of that bureau, which has been of inestimable work in furthering the application of chemistry and engineering in the paint and varnish industry. R. S. Perry served for two years as First Director of the Scientific Bureau, resigning in 1909 in favor of Henry A. Gardner, then assistant director and Mr. Gardner has served with eminent distinction since that time. The Scientific Bureau, established in its own extensive laboratories in Washington, D. C., now numbers eight investigators in its personnel.

The Educational Bureau, which had functioned to some extent prior to 1907, as an advertising committee of the Manufacturers' Association, was originally composed of six men. Today the Bureau consists of twenty-four of the leaders of the industry of which three—Norris B. Gregg of the National Lead Co., Ernest T. Trigg of John Lucas & Co., and Ludington Patton of the Pittsburgh Plate Glass Co.—were founders. Thomas Neal, W. J. Waugh and R. S. Perry were also founders and now are honorary life members, while G. B. Heckel of Philadelphia, has been Secretary of the Bureau since its original inception.

Lithopone. The tremendous growth in the lithopone industry from a production of about 10,000 tons per year in 1902 to over 145,000 tons in 1925, testifies to the commercial progress of this important pigment, but it does not tell the whole story of the early difficulties that beset the industry. The first plant of the Beckton Chemical Company had been established in Newark, N. J., about 1899 and was followed a year later by the plant in Philadelphia, both of which were controlled by Harrison Bros. & Co., which in 1917 became a part of

the du Pont company. John Cawley, vice-president of Cawley & Clark, dry color manufacturers of Newark, was general manager of the Beckton enterprise, and to him the credit should go for the technical success in the early production of lithopone in the United States.

The lithopone of 1902, however, was not the highly standardized and effective white pigment of today. Then it occasionally had the discomforting property of suddenly turning black under certain conditions of exposure to sunlight and moisture.

Naturally this peculiar property of lithopone was the source of a lot of trouble to the early industry. The problem was finally solved by the chemists of the New Jersey Zinc Co., who were able to connect the photogenic effects with the residual radio-activity in the zinc sulphide. This was corrected by a change of the manufacturing process with the result that non-darkening and thoroughly stable lithopone is now available.

Lead Pigments. White lead, that is the basic lead carbonate corroded by the old Dutch and Carter processes has been the backbone of the paint industry for so long that it has overshadowed some more recent developments in which chemical engineering has played an important part. The electrolytic method worked out by the Anaconda company is such a development. Another is the case of basic lead sulphate—sublimed white lead—which was first produced by E. O. Bartlett about 1876 at Joplin, Mo., but assumed prominence only after the early investigations of the Educational Bureau. Furthermore, it was not until Dr. John A. Schaeffer, J. H. Calbeck and B. S. White of the Eagle-Picher Lead Co., put its production on a thorough engineering basis that it reached its present position of importance among the lead pigments. In 1925 about 15,000 tons of basic lead sulphate were produced.

Other Pigments. Probably the most conspicuous advance among the new pigments that has come into use during the past few years has been the developments of the titanium oxide pigment "Titanox" which is produced by the National Lead Co., at its St. Louis plant. It was largely developed through research work in this country and in Norway—Meredith of the Titanium Alloys Co., and Gardner and Barton, being the names commonly associated with the American development.

Chemical engineering progress in the production of dry colors has been less spectacular, but has had a steady growth in the United States. In particular, we should recall the commercial development that has resulted from the vision and courage of C. K. Williams of Easton, Pa.

Tung Oil. About 1906 tung oil was regarded as practically useless to the paint and varnish industry. Today it is the basis for most of the oil varnishes and has an important application in enamel paints. This change of heart on the part of the industry resulted from the chemical and physical study of the characteristics of the oil, which eventually led to methods of avoiding the polymerization that normally occurs at comparatively low temperatures. Among the first to use tung oil successfully was the late Frank A. Lane of John Lucas & Co., who later joined Harrison Bros., and Samuel George of the British firm of Naylor Bros. & Co., Ltd.

The importance of tung oil to the domestic industry is attested by the fact that several thousand acres of tung trees have been planted in Florida—300 acres being owned by the American Tung Oil Corp., formed from the membership of the American Paint & Varnish Association, while a 2,500-acre tract is being developed by Benjamin Moore and Co.

Daylight Mill Lighting Enamels. Following the demonstration of the usefulness of tung oil and soya bean oil to the varnish maker, Herbert Rice of the United States Gutta Percha Paint Co., developed a process and vehicle for a new type of enamel paint. This product made by the Rice process has come into wide use as an interior paint in mills and industrial establishments. Other firms are now making somewhat

FRANK P. INGALLS

Since graduating in chemistry from Cornell in 1884, Mr. Ingalls has been continuously connected with the paint and varnish industry. As chemist and head of the technical service department of John W. Masury & Son, he has been active in the work of the A.S.T.M. since its inception.

ROBERT S. PERRY

Mr. Perry, whose reminiscences form the basis of the accompanying interview, was president of Harrison Brothers & Co. from 1902 to 1916 and played a prominent part in establishing the joint scientific work of the industry. Since 1916 he has been president of Perry & Webster, Inc.

M. J. CALLAHAN

Joining the duPont organization in 1916 Mr. Callahan served first as research chemist, then as assistant director of Redpath laboratory and at present is chemical superintendent in charge of work on all chemical problems related to the composition, manufacture and use of pyroxylin coatings.

ALVAH HORTON SABIN

When Professor Sabin resigned his professorship at the University of Vermont in 1886 to become chemist for Edward Smith and Co., he began a career that has done much to put the paint and varnish industries on a scientific basis. His long connection with the National Lead Co. is a feature.

similar products and a well defined branch of the paint industry was thus established on this chemical engineering development.

Ester Gums. The so-called ester gums were first brought into the United States about 1892, but in later years these combinations of rosin and glycerol have assumed tremendous importance and with tung oil may be regarded as the foundation for the varnish industry of the past twenty years. Other synthetic resins have been the focal points for research in many paint and varnish laboratories.

Pyroxylin Lacquers. Probably no other single development in the history of the paint and varnish industry has been so revolutionary in its effect as has been the growth and influence of the modern pyroxylin lacquers of the Duco type. Lacquers themselves were not new but the recent development lay in overcoming the difficulty that had always handicapped the lacquer manufacturer. The type of pyroxylin (nitrocellulose) previously available had the very undesirable property of giving a very high viscosity to solutions containing only a small amount of it. Accordingly, when one attempted to add sufficient solids to give the necessary covering power to the lacquer, it became so viscous that it could not be worked. The research laboratory of the du Pont company set to work on the problem and after several years investigation developed a type of nitrocellulose that gave solutions of low viscosity and thereby made it possible to increase by at least three times the amount of pyroxylin and solids that could be put into the solution.

It was this discovery that furnished the basis for the tremendous growth of the lacquer industry in which during the first six months of 1926 more than 10,000,000 lb. of pyroxylin lacquers were produced by 111 different plants. The names of the du Pont technical men most often associated with the Duco development include that of E. M. Flaherty and M. J. Callahan of the technical organization at Parlin, N. J., and Dr. C. M. A. Stine, chemical director, and Dr. H. B. Bradshaw, assistant chemical director, of the Experimental station at Wilmington, Del. The Hercules Powder Co., has been an important factor in lacquer development in that it has supplied the low-viscosity nitrocellulose from which many of the lacquers other than Duco have been produced.

Solvents and Thinners. Coincident with the lacquer development there has been a remarkable expansion in the production of the various solvents, plasticizers and other ingredients required in the manufacture of the new product. From the commercial as well as technical standpoint, the most important advance has been the large-scale production of butyl alcohol by the fermentation of corn. This achievement of the Commercial Solvents Corporation which was begun during the World War and since expanded at both the Terre Haute, Ind., and Peoria, Ill., plants, has also revolutionized the production of acetone which is obtained as a joint product with butanol and ethyl alcohol in the fermentation process.

Both butyl and ethyl alcohols and to a lesser extent amyl alcohol are the basis for many solvents that are essential in the production of lacquers. Among these are ethyl, butyl and amyl acetates, ethyl lactate, diethyl and diamyl phthalates.

The naval stores industry has taken a new hold on life in recent years due largely to chemical engineering development. The growth of the steam distillation process as developed by the Naval Stores Division of the Hercules Powder Co., under the direction of Joseph Lockwood, G. M. Norman and the late C. M. Sherwood, has been a contributing factor. So, too, has been the influence of the work on gum turpentines and rosin by the Bureau of Chemistry under F. P. Veitch and others. More recently the program of research at Mellon Institute undertaken by the Turpentine and Rosin Producers Association, points to further scientific progress in one of the most important of the industries that contribute

EDWIN F. LADD

The late United States Senator, the first chemist to be elected to that position, was foods and drugs commissioner in North Dakota at the time that state passed its now famous "pure paint" law of 1906. This legislation, brought about the beginning of the paint industry's first joint scientific studies.

E. M. FLAHERTY

Transferred in 1913 to Parlin, N. J., as a research chemist Mr. Flaherty's first problem was the adaptation of the pyroxylin enamels then being made to automobile finishing. Since 1925 he has been assistant manager of the chemical products division with responsibility for both manufacturing and sales.

HENRY A. GARDNER

Mr. Gardner has been in continuous charge of the Association's laboratories in Washington, D. C., since 1908. The work of this section, under Mr. Gardner's direction, has probably been the greatest single force in placing the paint and varnish industries on their present basis of scientific control and operation.

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DONALD A. KOHR

In 1901, shortly after graduation from Ohio State University, Mr. Kohr entered the employ of the Lowe Brothers Co. and since that time has been prominently identified with the paint and varnish industries. He is, at present, the vice president and general manager of the Lowe Brothers company.

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raw materials used for paint and varnish manufacture.

Aluminum Paint. The large-scale use of aluminum powder with suitable oil vehicles marks an important development in the paint industry. Aluminum paint had been used for many years but it is only within the past 10 years that there has been a wide recognition of its value as an exterior paint for iron and steel equipment. A particular important application has been in the painting of petroleum and gasoline storage tanks and other equipment where the metallic coat of aluminum reflects the sun's rays and keeps the oil cool—thus reducing evaporation losses. The development of aluminum paint has come largely from the laboratories of the Research Bureau of the Aluminum Co. of America. Dr. Junius D. Edwards, assistant director of research at New Kensington, Pa., has been most closely identified with the chemical engineering development of aluminum paint.

Fume Control. The chemical engineering development with which Mr. Perry has been most closely associated during this period has been the control of the fumes and condensible vapors produced during the process of manufacturing varnish. Although some early progress had been made abroad toward the solution of this problem, in order to reduce fire and explosion hazards, or to avoid the offensive and troublesome odors given off during the heating, blending and thinning of the vegetable oils, gums and resins, it was not until 1916 that the first complete and highly successful system was installed at a Rhode Island varnish plant, which because of its location in the midst of the city had found it necessary to discontinue manufacture, to move to another locality or to suppress completely all varnish fumes and odors. The last course was decided upon and equipment was designed so that a major fraction of the fumes from the varnish kettles were separated by surface condensation in long sheet metal flues as a byproduct known as copal oil. Another portion was separated out by water scrubbing and since residual offensive compounds were of an acid character, these were removed by scrubbing with alkaline solutions. The system operated successfully and other plants were similarly equipped.

Research and Technical Organizations. Reference has previously been had to the work and organization of the Scientific Section of the Educational Bureau of the Paint Manufacturers Association and with which the National Varnish Manufacturers Association is now consolidated. Some of the other laboratories that have contributed notably to the chemical and engineering developments of the industry include the following: National Lead Co., Brooklyn, under Dr. G. W. Thompson and R. L. Hallett, the New Jersey Zinc Co., Palmerton, Pa., where Dr. Frank C. Breyer is director of research, the du Pont Laboratories and Technical Organization under Leo P. Nemzek, technical director of the paint and varnish division, the Pittsburgh Plate Glass Co., Milwaukee, under Clare H. Hall and P. R. Croll. The Eagle Picher Co., under Dr. J. A. Schaeffer and J. H. Calbeck, the University of North Dakota under Prof. W. T. Pearce in charge of paint and varnish studies, the Valentine Co., under L. V. Pulsipher, and Lowe Bros., under D. A. Kohr. The work of the Bureau of Standards under Percy H. Walker and F. W. Smither and E. F. Hickson has resulted in many notable contributions. Other laboratories have contributed papers on paint and varnish.

American Contributions to Paint and Varnish Making

By Maximilian Toch

Vice-President, Toch Brothers, Inc.

THE first record we have of any pigments are those which were used on the tomb of Perneb in the ancient city of Memphis, 4,500 years ago. With the exception of the semi-precious mineral malachite and ground cobalt glass, known as frits, the other pigments, about five or six in number, were whiting, charcoal, ochre, hematite and one or two other colored earths of the nature of umber or dark ochre.

The pigments used on the Temple of Karnak many centuries later, showed that practically the same pigments were used, and on the sarcophagi where a little more fancy painting was done, boiled parchment (glue) and the white of egg were the only mediums.

Later, about the year 2,000, the Egyptians employed wax or semi-fossil resin and did a type of encaustic painting. About the twelfth century linseed oil was used in house painting and at the end of the fourteenth century, linseed oil was used as a medium in portrait painting. From that time to the end of the nineteenth century the paint industry stood still.

Within the last twenty-five years there has been the greatest advance in painting, far beyond that which has ever been dreamed of by our fathers or forefathers. Many oils have been added to the list of drying oils, notably chinawood oil which is of tremendous importance. The Varnish Manufacturers Association of the United States having recognized a few years ago that this country was suitable for growth of the tung oil tree, has established in Gainesville, Fla., a plantation where seeds are being already harvested and replanted so that eventually we hope to be independent of supply from China. If our foresight were as good as our hindsight, we would have started the plantation in 1912 and today we would have had our own wood oil grown in America.

But by far the greatest improvement in paint and varnish that has ever taken place is the advent of nitro-cellulose lacquers. Five years ago the amount manufactured and sold was negligible. The best estimates now obtainable are that in 1926 more than sixty million dollars worth of lacquer has been consumed in the United States alone. The most interesting and gratifying part of the lacquer industry is that every conceivable constituent of lacquer is indigenous to the United States and although some of the solvents may be imported, there is no necessity for doing this, as we produce everything here.

The improvement in the pigments has been very great within the last twenty-five years, for since then such permanent red dyes as the para-nitraniline, and toluidine reds have been perfected, and cadmium lithopone has been made; titanium pigments have come to stay and lithopone has been made light-proof.

Where twenty-five or thirty years ago only three or four paint and varnish concerns in the United States had real research laboratories, it is not an over-estimation to say that there must be close to a thousand paint, varnish and color chemists in actual employ today

Machine Speeds Have Increased in Paper Making

By W. G. MacNaughton
Secretary, Technical Association of the Pulp and Paper Industry

CHIEF among the advances in the art of paper making during the past 25 years has been the pronounced increase in machine speed. This increase in speed of the paper machine certainly has been the most marked of the various developments, and it unquestionably is more noticeable than any change in the paper making processes. Like most notable developments in the giant industries, the work of many men has contributed to the solution of the common problem, which in this instance is the accelerated production of paper, attaining at the same time lower costs, reduction of wastes, better working conditions and higher quality of products. The following men and their inventions, although possibly an incomplete enumeration, should rank as outstanding in the history of modern paper making.

Probably the leading invention was that of W. H. Millspaugh, of the Paper & Textile Machinery Company, Sandusky, Ohio, who developed a suction roll which was first applied to the couch and later to the lower press rolls. With him, however, should be included E. J. Trimbey of the Trimbey Machine Works, Glens Falls, N. Y., who is the inventor of the Trimbey consistency regulator, whereby the pulp suspension is brought automatically to a definite density and maintained at that point.

Another inventor whose work undoubtedly contributed towards the possibility of increasing the paper machine speed from about 400 ft. per minute in 1902 to about 1,100 ft. per minute at the present time, was William Eibel of the Rhinelander Paper Co., Rhinelander, Wis. Mr. Eibel developed what is known as the Eibel process, by which the fourdrinier wire is pitched from the head box to the suction couch. Although just about the time his patents expired in 1919 or 1920, and after they had been declared valid by the Supreme Court, it was found that paper machines could be operated quite as satisfactorily on a level. Nevertheless it must be agreed that the use of the Eibel process was a material factor in making possible increased machine speed.

Other inventors whose developments undoubtedly contributed materially to the same end were Elmer Pope and William Sheehan, both of whom died within the last five years. The inventions of these two men were in particular for transferring the sheet of paper during its formation from section to section automatically, or with mechanical appliances. At 500 ft. per minute it is possible for operators to handle the sheets between the sections, but when the rate of speed becomes increasingly great, it was found difficult to get operators who could do this successfully. Mr. Pope applied compressed air at the vital points by which the sheet was transferred. William Sheehan developed automatic rope carriers to take the sheet through the tier of drying cylinders, and at the present time all modern machines are so equipped. In addition to the inventions made, the increase in machine speed was still further assisted by the development of the sectional electric motor drive for the paper machines. The Westinghouse company was undoubtedly the first to apply such a drive to the paper machines, followed a year or two later by the General Electric Company. Just who are individually responsible for this important development is difficult to say.

The application of vacuum to paper machine drying by Ogden Minton, of Greenwich, Conn., is worthy of record. Although his semi-commercial machine was built only three or four years ago, it may be considered to be in commercial application at the present time, since a machine making paper 146 in. wide and 750 ft. per minute is now in operation at Price Brothers, Ltd., Kenogami, Quebec. Another machine is said to be under construction for the Bakelite Corporation, Bloomfield, N. J., and this should be in operation during the present year. It is rather difficult to select the names of men whose work has had a direct bearing on pulp and paper since, generally, the improvements have been more or less the application of processes and equipment found applicable to other industries.

R. B. Wolf, of the International Pulp Bleaching Corporation, New York City, has developed equipment for bleaching chemical pulp at high densities, and this process and equipment has been very widely adopted in the industry on this continent as well as in Europe. By this means, the pulp is bleached at materially higher densities than formerly, 18 to 25 per cent dry, at a great saving in the heat formerly required, and it has other advantages also.

In the preparation of wood for pulp, the outstanding development is without question the use of the barking drum to remove the bark instead of the disk knife barker which formerly was universally in use, and which caused a waste of wood approximating 25 per cent by volume. Although various attempts have been made to bark the wood with less waste, it was not until about 1914 that H. W. Guettler of the Fibre Making Processes, Chicago, invented the barking drum which is a continuously operating machine.

In the fundamental study of pulp manufacture, the work done at the Forest Products Laboratory, Madison, Wis. by J. H. Thickens and G. C. McNaughton on

mechanical pulp, as well as that done by J. D. Rue, R. N. Miller, W. H. Swanson and others on the sulphite pulp process, is well worthy of record. In paper technology, J. A. DeCew, president, Process Engineers, New York City, in his work on rosin sizing processes, and the invention of a rosin soap emulsifier, has taken rosin sizing out of rule of thumb operation and has placed it under scientific control.

There have been no radical developments in paper products except that of cellucotton by Ernst Mahler of the Kimberly-Clark Company, Neenah, Wis. This is an artificial cotton wood pulp which was developed during the War for surgical use and which has since become a very important article of manufacture. In the fibre-making processes, while the semi-chemical process was developed at the Forest Products Laboratory by J. D. Rue and others, it has been applied commercially in a number of plants for the utilization of otherwise waste material in manufacturing paper board. A still more recent development is the Mason Fibre Process whereby sawmill waste after being chipped is exploded from guns by high-pressure steam, the product being made into insulating board. This is the invention of W. H. Mason, Laurel, Miss., who presented a paper on this subject before the recent annual meeting of the Technical Association of the Pulp & Paper Industry. The process is in commercial operation at the Mason Fibre Co., Laurel, Miss., and is considered to be the outstanding development in fibre making of the past century.

As yet, byproduct utilization has not made satisfactory progress. Although it is now standard practice to reburn the lime used in causticization, many other savings remain to be effected. A conspicuous leader in technical control and byproduct utilization has been the Brown company, of which Hugh K. Moore is the technical director. Just what problems will be attacked within the next few years is difficult to say; those related to stream pollution, however, are likely to receive much attention, not only because savings may be possible, but because of increasing legislative pressure.

The greatest single development of the last quarter century is rather difficult to select. Of the equipment that has contributed the most to the present stage of development in paper manufacture, W. H. Millspaugh's suction roll should probably have first place. Among the new products of the greatest importance cellucotton probably ranks the highest. In process work, although it may be too early to make a positive statement, it is generally believed as has been already said, that the explosion process for fibre production from the waste of saw mills and the development of artificial lumber by W. H. Mason, is the outstanding development not only of the past 25 years, but of the past 100 years.

The preparation and publication of the set of textbooks for study and reference entitled "The Manufacture of Pulp and Paper" must be recognized as an extremely important achievement of the paper industry of North America. For the initial preparation of these books during 1916 and 1917, manufacturers of pulp and paper contributed $50,000, and as a result all of the essential knowledge of the art has been concentrated in a few volumes written by recognized authorities on both the theoretical and practical aspects of the industry. Another educational development of importance has been the establishment of complete courses in the chemistry of pulp and paper in the University of Maine and in Syracuse University. These courses have been in operation for about 14 years and the results have justified fully the expectations of these institutions.

J. A. DE CEW

To J. A. DeCew, president, Process Engineers, Inc., of New York City, belongs credit for the invention of a rosin soap emulsifier that has taken rosin sizing processes out of the rule of thumb class and has placed this important phase of paper technology under rigid scientific control. This process is unquestionably one of the important developments of modern paper making.

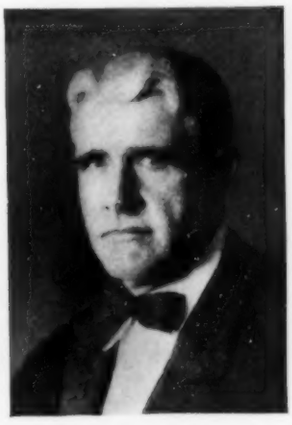
Alman & Co.

W. G. MAC NAUGHTON

Upon graduation from McGill University in 1904, Mr. MacNaughton became chemist for the Canadian Consolidated Rubber Co. From 1908 to 1921 he was identified with the paper industry in various technical and executive capacities from chemist to plant manager. In 1921 he became secretary-treasurer of the newly formed Technical Association of the Pulp and Paper Industry.

JOHN D. RUE

Mr. Rue has directed many fruitful investigations including control of sulphite pulping processes; handling and storing pulpwood and groundwood pulp; modified cooking process for straw; hardwood pulping process; modified kraft process; and the rod mill reduction process. He is now in charge of the section of pulp and paper, Forest Products Laboratory, Madison, Wis.



W. H. MASON

Before developing his process for exploding wood into fibre, and organizing the company of which he is vice-president and general manager, Mr. Mason was long associated with Thomas A. Edison and during the War he was general superintendent of construction of the Merchants Shipbuilding Corporation, Bristol, Tenn., the twelve-million-dollar yard for which he built in one year.

Electrochemical Industries of the Twentieth Century

IN THE early nineties, James Turner Morehead, George F. Seward, August Neresheimer, August Eimer and Thomas Willson joined in an enterprise at Spray, N. C., to manufacture aluminum metal in the electric furnace. This was called the Willson Aluminum Co. Curiously enough, experiments made by Willson on his aluminum development led to the founding of the modern carbide industry.

Searching evidently for a suitable flux for the aluminum process, Willson charged the furnace with lime and carbon, the immediate result was so disappointing, however, that the charge was thrown on a scrap heap. Following a severe rainstorm, one of the employees unintentionally threw a lighted match on the heap, which to his surprise burst into flames. In order to identify the product, Prof. Kinnicutt of Worcester Polytechnic Institute and Prof. F. P. Venable of the University of North Carolina were consulted. The black mass proved to be calcium carbide and the gas acetylene. Shortly thereafter calcium carbide was made at Holcomb Falls on the James River near Lynchburg, Va. In the larger furnaces the product was crystalline.

LOUIS KAHLENBERG

After studying in the Universities of Wisconsin and Leipzig, Dr. Kahlenberg became professor of chemistry at Wisconsin, a connection that he still retains. Besides being the author of several well known texts, he has published numerous papers on his researches in electrochemistry, physical chemistry and colloid chemistry. He is known also for his consistent opposition to the electrolytic dissociation theory of Arrhenius.

No sales promotion work had been done and, consequently, a market was needed. An offer of $125,000 from the Peoples Gas Light Co. of Chicago to purchase the carbide patent was accepted. Subsequently the process has probably yielded $25,000,000 in net profits for its owners. The development of ferro-alloys was next taken up, answering a call from Theodore Roosevelt, then Secretary of the Navy, for chrome alloys needed in the Krupp armor plate which had been adopted by the new navy of the United States.

With the help of a chemist named Chalmont, 85 per cent chromium was produced for the large steel companies, the Carnegie Steel Co., the Bethlehem Steel Co., the Maryland Steel Co., and the Firth-Stirling Steel Co. This development led to the construction of another plant at Kanawha, W. Va., which developed 4,000 hp. Besides ferrochrome, patents were obtained on silicon carbide, titanium and silicon. In 1907 the Carbide company purchased the Kanawha Falls plant, forming the Electro Metallurgical Co., still one of the divisions of the Union Carbide & Carbon Corp.

One of the first of the serious difficulties in ferrochromium production was scarcity of satisfactory chrome ore. Chromite was first imported from Turkey. Both the Maryland and North Carolina ores proved to be unsatisfactory. Ore was finally obtained from New Caledonia.

Another source of trouble was the electrodes. The first electrodes were imported from Nuremberg, but the development of Acheson electrodes solved these troubles. The first small furnace was gradually enlarged until a furnace of 25 ft. dia, and 25 ft. high was attained. The electrodes for such a furnace were 12 to 16 in. in diameter, and could be consumed with a minimum of waste.

Ever widening applications as a material of construction with consequent large-scale production have been the high spots in the history of the modern aluminum industry. Domestic production of the metal in 1890 was only 45,000 lb. in contrast with an estimated production of 175,000,000 lb. for 1926. During the same time production facilities have increased from one room in an old mill building on Smallman Street in Pittsburgh to a chain of works extending from Alcoa, Tenn., Badin, N. C., Niagara Falls, and Massena, N. Y., to Shawinigan and Arvida, Canada.

The technology of electrolyzing alumina in a bath of fused cryolite has not changed fundamentally since C. M. Hall's patent of 1886, which is both a tribute to Hall's thoroughness as an inventor and an indication of the difficulties of winning the metal from its ores. There have, however, been notable advances in the technology of the metal itself. Despite widespread opinion to the contrary, at least ten aluminum solders are known, and the autogenous welding of aluminum has been so perfected that soldering is essential in but few constructions.

The major advance since Hall's patent was William Hoopes' process of refining aluminum, using a molten aluminum copper anode and a molten cathode in a molten electrolyte. Aluminum refined by this process is said to contain less than 0.02 per cent of impurities.

The problem of adding nitrogen to carbide at which Moissan failed in 1894, was solved in the following year by Professors Frank and Caro. After years of effort the process was put in production in 1905 at Westeregeln near Magdeburg, Germany. This plant produced 800 tons of cyanamid during its first operating year, but was not a permanent success. In the same year another plant was started at Piano d'Orta, Italy. The plant had an initial capacity of 4,000 tons per year, and this was increased gradually until 1913 when an output of 24,000 tons was attained.

In Germany, the first large cyanamid plant began operations in 1907 at Bramberg, Prussia. This was followed in 1909 by a plant at Trostberg, Bavaria, which now has a yearly output of about 200,000 tons of cyanamid per year.

The first cyanamid plant in North America was built in 1909 at Niagara Falls, Canada. The Niagara plant first obtained its nitrogen by passing air over heated copper, the copper being regenerated with natural gas. Several years later, liquid air machinery was perfected in Europe, and after 1914 all additions to the Canadian plant were equipped with this machinery. The superiority of nitrogen produced by the rectification of liquid air both in cost and in quality of product marked an important advance in the cyanamid industry.

The initial capacity of the Niagara plant was 5,000 tons of cyanamid per year, and this has grown steadily until present production is at the rate of 120,000 tons per year. The only cyanamid plant within the borders of the United States is the U. S. Nitrate Plant No. 2 at Muscle Shoals, Ala. This plant was built in 1918 and had a rated capacity of 110,000 tons of ammonium nitrate per year, the nitrogen being fixed as cyanamid. It began operations shortly before the Armistice and after a brief operating trial it produced about 2,000 tons of ammonium nitrate. It is now maintained in standby condition. As far as is known, it is the only fully-equipped cyanamid plant in the world which was not operating in 1925-1926.

Due to variations in the quality of carbide and in the method of working the process, cyanamid is not uniform throughout the world, and there may be a wide variation in nitrogen content. Most cyanamid produced outside of the United States contains less than 20 per cent of nitrogen, and some of the European product contains only 16 to 17 per cent of nitrogen.

During the past 15 years little or no progress has been made in Europe toward increasing the nitrogen content in the product and most of the plants are now producing the same grade that they did years ago. In America, however, the policy of the industry has been different. From the beginning an effort has been made to increase the maximum quantity of nitrogen. Starting in 1910 with a product containing 16 to 17 per cent of nitrogen, the cyanamid produced today has an average nitrogen content of 23.5 per cent in the crude material before conversion to fertilizer. Power economy has also improved. The earliest records show a consumption of about 3 hp.-yr. per short ton of nitrogen. At present the American energy consumption is less than 2 hp.-yr. per short ton of nitrogen. Furthermore, the consumption of raw materials has decreased steadily, and so has the labor requirement of the process.

The last ten years of the Nineteenth Century marked the beginning of the end of British domination of world markets in heavy chemicals. The setting up of tariff walls by the United States and Germany began to affect the exports of alkali and bleach. The well-known brands of LeBlanc products continued to go to the other foreign markets. Although the Solvay process flourished, the LeBlanc process in spite of its many activities, began to decline. It met resistance from the Deacon process which became successful through the improvement made in 1883 by Hasenclever. Another setback to the LeBlanc soda industry was the development of the Louisiana sulphur deposits by Frasch. This forced a number of the Chance sulphur recovery plants to cease operations. When the United Alkali Co., erected a solvay process plant it was apparent that the LeBlanc manufacturers were at least losing faith in the process they had so carefully promoted.

H. W. GILLETT

Dr. Gillett's researches date from 1910 when he made temperature measurements in a carborundum furnace. From 1912 to 1924 he investigated brass melting; developed the rocking arc furnace and electric smelting processes for uranium ores and low-grade manganese ores. In 1924 he left the Bureau of Mines to become chief of the division of metallurgy, Bureau of Standards.

D. A. PRITCHARD

D. A. Pritchard was trained in England as an electrical engineer. From 1910 to 1915 he was connected with various American companies, after which he was in charge of the electrochemical plants then being installed by the United Alkali Co. In 1922 Mr. Pritchard came to Canada to be works manager of the Canadian Salt Co. of Windsor, Ontario, a position which he now holds.

S. SKOWRONSKI

For twenty years S. Skowronski has been prominent in the American Electrochemical Society, particularly in the affairs of the New York Section. He has long been identified with the electrometallurgy of copper and is research chemist for the Raritan Copper Co., Perth Amboy, N. J. The specific conductance of copper electrolytes is now being studied by Mr. Skowronski in the Raritan laboratories.

W. S. LANDIS

In the fifteen years that W. S. Landis has been with the American Cyanamid Co. he has had an active share in many developments, including ammonia oxidation, the production of ammonium phosphatic fertilizers, the production of cyanide from cyanamid, the production of nitric acid from ammonium nitrate and the production of anhydrous hydrocyanic acid, as well as cyanide salts or derivatives.

When the Castner mercury-cathode cell was installed on a commercial scale at Weston Point in 1897, close to the Solvay industry and using brine from the same source, the LeBlanc manufacturers must have sensed that their process was doomed. The electrolytic process made a purer caustic soda and a stronger chlorine gas, required less labor for operation and eliminated waste of raw material. The LeBlanc process lingered until the War in 1914 when it received temporary encouragement from emergency requirements of chlorine. In 1915 the United Alkali Co. closed all of its LeBlanc plants and installed the electrolytic process.

The modern development and progress of chlorine production, aside from the development of electrolytic cells, is closely related to the increased use of liquid chlorine and the decrease correspondingly of bleaching powder. Commercial liquid chlorine made its appearance in Germany in 1888 and from that time began to displace bleaching powders. This condition did not, however, begin to affect the bleaching powder industry in the United States and in Canada until 1909. German manufacturers made strong effort to introduce liquid chlorine into England and into the United States, but the traditional use of bleaching powder by the English and the strong position of the LeBlanc process proved to be formidable resistance.

Liquid chlorine from Germany was not profitably exported to the United States as there was a heavy duty on steel containers and bothersome detail in the customs that greatly delayed shipments. These conditions made arrivals uncertain and insurance and carrying charges were increased. When the manufacture of liquid chlorine was introduced in the United States in 1909 and in Canada in 1922, the market for bleaching powder began to decline steadily. This decline is still in progress.

ALTHOUGH much progress has been made in the practice of electrolytic refining, this is as nothing compared to the advance in theory. Twenty-five years ago empiricism dominated, and copper was about the only metal refined on a large scale by electrolytic methods. Many mechanical improvements and improved yields have resulted from the intensive study of copper refining, but there has been little change in the metallurgy of the process. Even addition agents were known if not fully appreciated 25 years ago, and furnace operations have been virtually unchanged for a much longer time. Many of the early defects of the process remain; cyclical instead of continuous furnace operations, cumbersome slimes treatment; appreciable losses of metal; and lack of control of the physical characteristics of product.

The technology of copper refining has been applied to the treatment of other metals as for example, gold, silver, lead, zinc, tin, iron and a few others.

Each of these applications has introduced special problems, most of which have to do with the composition of the electrolyte and the control of the cathode deposit. Curiously enough, zinc refining was retarded for years by the mistaken idea that pure zinc was readily soluble in dilute sulphuric acid.

The electrolytic treatment of liquors obtained from the leaching of copper ores now enjoys wide application, the temporary setback from the rapid development of flotation having been overcome. It is possible that electrolysis will be applied to intermediate products such as concentrates, as more is learned about leaching methods. A complication arises, however, from the usual presence of gold in copper concentrates.

PRIOR to 1900, little was accomplished in the art of electrostatic precipitation or separation of solid or liquid particles from gases. The first real advance was made from 1905 to 1910 when Dr. F. G. Cottrell, then assistant professor in the University of California, demonstrated successfully a high-voltage mechanical rectifier that could be used to produce undirectional current for electrostatic precipitators.

Furthermore, Cottrell developed the various combinations and designs of electrodes for such a process, and he developed means for collecting the precipitated solids or liquids. In 1912 W. A. Schmidt completed the first large-scale dust collector applied to the cement industry at the Riverside Portland Cement Co., Riverside, Calif. Schmidt operated at voltages of from 50,000 to 75,000 volts, using wires and strips as discharge elements for electrodes and screen plates as collecting elements. In 1913 Cottrell showed that a negative discharge resulted in smoother operating characteristics, and that this would give more effective precipitation than the positive discharge.

In 1916 and 1917 Schmidt and Bradley demonstrated the advantages of humidification especially in the precipitation of non-conducting materials such as zinc oxide.

In 1923 and 1924 Schmidt and Anderson developed an improved collecting electrode known as the "graded resistance" electrode, which comprises a special cement mixture applied in the form of a plate with embedded conductors placed in such relation to the discharge electrode that a poorly-conducting medium was placed in series with the spark gap between the discharge electrode and the embedded grounded conductor. This improvement made possible a greatly reduced size of precipitator, operating without serious arcing and uniformly precipitating the dust contained in the gases.

The developments during this period were paralleled in other countries, particularly in Germany, so that the trend throughout the world was much the same. Since 1913 there has been a liberal interchange of information between the United States and European countries and this has done much to promote developments in this art. At the close of 1925 more than 300 Cottrell installations were in operation throughout the world. The principal industries to which the process has been applied are portland cement manufacture, metallurgical industries, recovery of sulphuric acid, cleaning hot sulphur dioxide gases and detarring illuminating gas. The total investment in Cottrell precipitation plants in the United States alone is at least $10,000,000, and in other parts of the world $3,000,000.

RESEARCH on the fixation of atmospheric nitrogen began in 1781 when Cavendish made nitric acid by burning hydrogen in the air. Not until 1902, however, was nitrogen fixation attempted on a large scale. In that year the Atmospheric Products Co. was organized with a capital of $1,000,000. This company operated on the process developed by C. S. Bradley and R. Lovejoy at a plant at Niagara Falls, N. Y. Thus there was founded on American territory the first plant for the commercial fixation of atmospheric nitrogen. The plant closed in

1904 after two years of operation because of the high cost of the process.

The Norwegian process developed by Birkeland and Eyde proved, however, to be a technical and economic success. This process was the beginning in Norway of the industry which in 1903 consumed 150 hp. and which now consumes about 320,000 hp. The company exploiting this successful venture is the Norwegian Hydro-Electric Nitrogen Co., two large plants of which are located at Notodden and Rjukan, the combined annual output of these two plants being 35,000 metric tons of fixed nitrogen.

Although attempts to produce ammonia direct from nitrogen and hydrogen were made as early as 1807, nearly a century elapsed before Prof. Fritz Haber published his important papers on the subject in 1905 and 1906. In 1910 the Badische Anilin and Soda-Fabrik became interested in this method for the fixation of atmospheric nitrogen and built a plant in 1913 which successfully produced 7,000 tons of nitrogen per year.

From this beginning, the world's capacity of direct synthetic ammonia process plants has increased in 13 years to a rated operating capacity of more than 700,000 metric tons of nitrogen per year. This is more than double the installed capacity of the cyanamid and arc processes combined. After the plant of Bradley and Lovejoy stopped operations, interest in the fixation of atmospheric nitrogen in the United States practically ceased for several years.

In 1907 F. S. Washburn after studying the industrial possibilities of the cyanamid process in Europe, incorporated the American Cyanamid Co. The first plant, which had an annual capacity of 5,000 tons of cyanamid, was put in operation in 1909. Enlargements and improvements since that time have increased the capacity to 120,000 tons of cyanamid per year.

Another, but unsuccessful attempt to establish the cyanamid industry in this country was made by Prof. J. E. Bucher, the inventor of the Bucher process. The exploitation of this process was undertaken by the Nitrogen Products Co., and experimental plants were built at Saltville, Va., and Greene, R. I. In 1918 the Government built a plant at Saltville designed to produce 10 tons of sodium cyanide per day by this process. Operating costs proved to be too high to render the plant commercially practicable, however, and operation was discontinued in December of 1918.

Another and somewhat more successful attempt to establish the arc process in this country was that of the Southern Electrochemical Co., which built a plant in 1913 using the Pauling furnace and equipped for nitric acid concentration and ammonium nitrate production. This plant was never operated successfully as production costs were far too high.

Not until 1917, or 15 years after the attempt by Bradley and Lovejoy, did the first permanent plant go into operation in this country. This was the arc process developed by the American Nitrogen Products Co., at La Grande, Wash. This plant has a daily capacity of about 1 ton of fixed nitrogen. As far as known, no other attempt to exploit the arc processes has been attempted in this country.

The actual application of the electrical furnace to brass melting has been a development of the last 15 years. During the years 1912 to 1917 the fundamental research on brass melting was done. As early as 1905, Dr. E. F. Roeber clearly stated the advantages of electric melting, such as the reduction of zinc losses, elimination of crucible costs and larger output. He pointed out the importance to the central station of the potential brass furnace load.

Important experimental work was done by Baily, Bennett, Hering, Northrup and Wyatt, who were designers of furnaces; by Bassett, Clamer and Webster, executives in the brass industry; by Crosby and St. John of the central stations; and by Lohr, Mack, Rhoads and H. W. Gillett in the U. S. Bureau of Mines.

FROM the pioneer experimental work it became plain that the type of electric furnaces used for melting steel were not applicable to brass and that special types of furnaces must be developed. Four important types resulted, the reflected-heat type, of Baily; the vertical-ring induction of Ajax-Wyatt; the high-frequency induction of Ajax-Northrup; and the rocking arc of Detroit. Many variations of these fundamental types appeared, but few survive. The reflected-heat type furnace reached the height of its popularity about 1920 and has been falling into disuse since that time.

Baily's pioneer work should receive due credit for helping emphasize the fact that an electric furnace would work and would reduce metal losses. Although the thermal efficiency of the Baily furnace was too low to keep it generally in service, his competition with more efficient types, the development and commercial introduction of the furnace was no small factor in bringing about the present status of electric melting.

Experience with these obsolete or idle furnaces has been of value in developing knowledge of correct design and use. Counting experimental furnaces and the idle and obsolete furnaces just mentioned, the active furnaces in this country and those sold abroad, more than 1,000 electric brass furnaces have been built in the United States. An idea of the progress made by electric melting can be gained by the survey of present conditions. About 25 per cent of the type metal is electrically melted. Electric melting is virtually standard for nickel and its alloys. About 90 per cent of the output of brass, bronze and nickel-silver from the rolling mills and nearly 30 per cent of the output from foundries is melted in electric furnaces. The proportion of electrically melted metal is much greater in the brass industry than in the steel industry. About 675,000 tons of brass, bronze and nickel-silver were electrically melted in 1926 and this required 180,000,000 kw.-hr. Electric brass furnaces used $3,000,000 of electric energy in 1926, saved 40,000 tons of fuel, and saved 13,500 tons of metal that the fuel-fired furnaces would have lost. The value of this saved metal is about $2,500,000 a year. Electric brass melting has developed to the point where there are about 625 electric furnaces in active use in the United States and in Canada. These furnaces are distributed among about 175 different companies.

In preparing this brief review of the electrochemical industries during the past twenty-five years, *Chem. & Met.* acknowledges the co-operation of the American Electrochemical Society for permission to use material from the following contributors: Junius D. Edwards, W. S. Landis, D. A. Pritchard, Lawrence Addicks, P. E. Landolt, F. A. Ernst and H. W. Gillett.

NEWS *of the Industry*

Large Attendance at Spring Meeting of A. C. S.

MORE THAN 1,200 chemists and guests from the industries and universities of the South attended the Spring Meeting of the American Chemical Society in Richmond, Va., April 11 to 16. Wide interest was shown in a technical program of about 300 papers many of which dealt with the problems of such southern industries as textile dyeing and finishing, fertilizer manufacture, ceramics, lime and related developments. A symposium on the Technology of the Production and Use of Lime, led by Prof. James R. Withrow of Ohio State University, developed the relation of that industry to the manufacture of chemicals, pulp and paper and textiles. Papers presented before the dye division covered the application of dyestuffs to textile fibers from a theoretical and practical standpoint. Technical sessions were also held by the Divisions on Paint and Varnish, Petroleum, Rubber, Gas and Fuel, and Sugar.

The new laboratory of the University of Richmond was dedicated at a special session on April 11, at which Prof. E. Emmett Reid of Johns Hopkins and Dr. Charles H. Herty of New York were the speakers. Excursions to the University of Virginia at Charlottesville and to such historic centers as Williamsburg and Jamestown proved popular social features of the meeting.

Action was taken on several matters of society business and organization at the council meeting on April 11. Three new local sections were authorized in Porto Rico, Northern Ohio and at Princeton University, making a total of 73 throughout the United States and its insular possessions. The recommendations of the Committee on Entrance Requirements that the society set up Junior and active grades of membership with certain nominal qualifications for each was bitterly opposed by representatives from New York and other sections and was finally laid on the table after the council had held that no change in entrance requirements was necessary or desirable.

The bill proposed in the last session of congress by Senator Ransdell for the establishment of a National Institute of Health was explained to the council by Dr. Charles H. Herty and received a unanimous vote of approval.

Plans for national meetings during the next two years were announced with invitations for subsequent dates. The Fall Meeting this year will be held in Detroit during the week beginning Labor Day, September 5. The Spring Meeting in 1928 will be at St. Louis followed by a Fall Meeting with the Northeastern Section at Swampscott, Mass. Invitations were received for an April, 1929, meeting at Columbus, Ohio; September, 1929, at Chicago; April, 1930, at Atlanta, and September, 1930, at Cincinnati.

Prof. S. W. Parr was elected to succeed Dr. George D. Rosengarten as a member of the Executive Committee of the Society. At a business session held April 12 Honorary membership was conferred upon Prof. Richard Wilstatter, an eminent organic chemist at Munich. Two other German chemists. Wilhelm Ostwald and Walther Nernst were restored as honorary members, having been dropped during the hostilities of a decade ago.

Reduction Sought in Duty on Manganese Ore

AN APPLICATION for reduction in the duty on manganese ore has been filed with the Tariff Commission. It is contended that the consumers of manganese in the United States are being required to pay out $3,000,000 annually to support $300,000 worth of domestic production. The suggestion also has been made that the present duty be retained on chemical manganese, but that relief be given the consumers of metallurgical ore.

Kauri Gum Control Board Holds First Meeting

THE New Zealand Kauri Gum Control Board has been organized and held its first session on March 31, according to a report from Consul General Lawrie at Wellington. The board decided that it would not interfere with the exportation of gum at the present time and it will give three months notice of any proposed action. Under the Kauri Gum Control Act the board may assume control of the trade in Kauri gum, prohibit the exportation of gum except under license, purchase and sell gum under its control, and promulgate regulations for the grading, mixing cooling. and storing of gum.

New Source of Borax Found in California

THE Pacific Coast Borax Co. has begun mining operations on its holdings near Amargo in the Kramer district, about 30 miles east of Mojave, Calif. Although known to the officials of the company for some time that the deposits here contain a new mineral, commercial development work had been postponed until prospecting with core-drills proved the ore warranted the establishment of operations on an extensive scale.

The new mineral which is a previously unknown hydrate of sodium borate, containing four molecules of water, has been erroneously called "Kernite" by several writers. Those who have been responsible for the finding of this mineral have named it "Rasorite" as a tribute to C. M. Rasor, the field engineer of the company.

In appearance, rasorite is a transparent crystal, shaped as a long needle. It is tasteless and effloresces upon exposure to the air. The total extent of the rasorite deposit is not yet exactly known but core-drilling has proven an average thickness of 80 ft. over an area of 40 acres. It is 400 ft. beneath the surface and is directly overlain by a 60 ft. stratum of shale carrying ulexite and colemanite. The colemanite and ulexite deposit is known to extend for 5 miles east and west and about one-half mile north and south. The geology of the district has been described by L. F. Noble in U. S. G. S. Bulletin 785-C, written prior to the discovery of rasorite.

The Pacific Coast Borax Co. is hurriedly equipping the mine so that it will have a productive capacity equal to the entire world's consumption of borax. A small prospect shaft was sunk at first. This shaft is now producing 50 tons daily. A large three-compartment shaft is being sunk and is now down about 230 ft. In addition to this, a hoisting plant, steel head frame, steel ore bins, etc., are now being installed. This equipment when installed can produce about 400 tons per day.

The mine is but three miles from the main line of the Santa Fe railroad and about 140 miles from the company's shipping facilities at the Los Angeles harbor, the property being 900 ft. of waterfront at Wilmington, Cal. The Santa Fe is now building a spur track from the main line to the deposit.

Contracts Discussed at A. I. C. Conclave

AT THE first annual conclave of the American Institute of Chemists at Yale University, New Haven, Conn., March 28, the subject of contracts between employers and employees in the chemical industry was discussed from several points of view. The standpoint of the employer was presented by Dr. L. V. Redman of the Bakelite Corporation; the position of the employee was considered by Dr. W. M. Grosvenor and Dr. Lloyd VanDoran, consulting chemists; and the underlying principles of employment contracts were analyzed by Prof. Arthur L. Corbin of the Yale Law School.

The principal items in contracts, as indicated by their frequency of occurrence, deal with assignment of patents to the employer, non-disclosure of technical information to competitors, salary, term of employment, dismissal, engaging in competing lines of business, special compensation, vacations and sickness. Stress was laid on the ethical and moral character of a contract. It should be a code of ethics rather than a bill of restrictions, and men should be trained to observe its moral obligations. Prof. Corbin said that a contract should be so drawn as to square with the prevailing notions and feelings of the community. He favored a standard form of contract saying that it can and should be developed by cooperation among representatives of employers, employees and the public. Formal action was taken by the Institute on this latter suggestion and a committee will be appointed to study the matter and suggest a standard form.

The meeting closed with a banquet and address by W. S. Jardine, Secretary of Agriculture on "Agriculture and Modern Science."

Aldehol Used in Alcohol Denaturing Formula

NO CHANGE in the policy or organization of the Technical Division is to be made as the result of the law changing the Prohibition Unit to the rank of a bureau of the Treasury department, it is stated in Washington. Dr. J. M. Doran, chief chemist of the prohibition agency, will continue as chief of the Technical Division under the reorganization.

The principal effect of the new law, which became operative April 1, is that all authority formerly held by the Commissioner of the Bureau of Internal Revenue, of which the Prohibition Unit was a subordinate branch, has been removed. Appeals from rulings of the Commissioner of Prohibition must be taken directly to the Assistant Secretary of the Treasury having jurisdiction over the Prohibition Bureau, this position now being held by Gen. L. C. Andrews.

Officials of the Technical Division of the Prohibition Bureau are greatly interested in the results to be obtained from the use of a new formula for making industrial alcohol unsuitable for beverage purposes. Effective April 1, aldehol, the trade name for oxidized kerosene, became the mixture which must be added to industrial alcohol to prevent its diversion and use as a beverage. This dilutent creates an unpleasant taste and is nauseating but it is not a deadly poison. It will be some weeks before the alcohol now being prepared in this way gets into the channels of commerce.

Business Leaders To Meet in Washington

A DISTINGUISHED list of speakers, including President Coolidge and Secretary of Commerce Hoover, will address the Fifteenth Annual Meeting of the Chamber of Commerce of the United States which will open in Washington, May 2. This national gathering of business leaders from all parts of the country has been called for the purpose of discussing the important economic changes that have taken place in the business life of the nation during the last few years. The discussions will center around the major topic, "The New Business Era." President Coolidge's talk will be delivered before a joint meeting of the National Chamber and the Pan-American Commercial Conference. The latter conference will be attended by representatives from the Latin-American countries and will be held in Washington during the week of the meeting of the National Chamber.

Synthetic Methanol Produced on Commercial Scale

MANUFACTURE of synthetic methanol on a commercial scale has been established at Belle, W. Va., where a plant is being operated by Lazote, Inc., affiliated with the du Pont interests. Two years of intensive research and experimental work have resulted in the development of a new and purely American process, radically different from and an improvement over the foreign processes which, a few years ago, started to revolutionize the wood alcohol industry. There has been wide interest in the possible development of methanol in this country and it had been expected American producers would operate under the French or German patents.

The new plant, operated in conjunction with Lazote's synthetic ammonia manufacture, produces methanol from carbon monoxide and hydrogen under enormous pressures and at high temperatures. The commercial units now in production were built after an experimental plant had been operated satisfactorily for six months. The operations have been so successful that plans have been drawn to allow for plant expansion sufficient to meet the entire American demand for methanol.

Tariff Commission Wins Sodium Nitrite Case

DECLARING the case moot inasmuch as the President has declared an increase in duty under the terms of the flexible provision of the Tariff act, the United States Supreme Court April 11 remanded to the District of Columbia Court of Appeals, with instruction to dismiss, the suit of the Norwegian Nitrogen Products Co. against the Tariff Commission.

In 1923, the commission started an investigation of costs of producing sodium nitrite. The Norwegian Nitrogen Products Co., insisted upon the right to cross examine the commission's agents during the public hearing and demanded the right to see costs of production of American producers. Both motions were denied by the commission.

The Norwegian company sought a writ of mandamus in the District of Columbia Supreme Court, which sustained a demurrer by the commission. The importers appealed to the District of Columbia Court of Appeals. While this appeal was pending, the commission completed its report and sent it to the President, who thereupon issued a proclamation increasing the duty on sodium nitrite. The Court of Appeals held the case moot, in view of the action by the President, the matter having passed out of the hands of the commission, and the importers appealed to the Supreme Court.

In its decision, the Supreme Court agrees that the case was moot before the decision by the Court of Appeals and therefore declines to go into the issues originally involved. Not only did the Court fail to touch upon the right of the commission to keep individual costs of production in confidence but it also ignored the question of the constitutionality of the flexible tariff.

Conference on Oil Power at Penn State

OIL POWER is the subject of a conference to be held April 21-23 at State College, Pa. under the auspices of The Pennsylvania State College. Among the subjects under discussion will be "Economic Results of Possible Improvements in Oil Engine Combustion Systems," by E. J. Kates; "Oil Power from the Standpoint of the Oil Man," by E. D. Ries; "Petroleum Production—Past, Present and Future," by George H. Ashley; "What Is A Bearing?" E. G. Gilson; "Oil Engines for Automotive Use," by Edmund B. Neil; "The Centrifugal Purification of Oil," by Henry Moore; "Co-ordination of Oil Engine Research," by Robertson Matthews; "Oil Spray Investigations of the National Advisory Committee for Aeronautics," by W. F. Joachim; "Oil Spray Investigations at the Pennsylvania State College," by P. H. Schweitzer. Prof. E. D. Ries is Chairman of the Conference.

Injunction Suit Against Potash Producers

THE Department of Justice has filed injunction suit under the Sherman Anti-Trust Law and the anti-competition provisions of the Wilson Tariff Act, in the United States District Court at New York city, against a group of German and French producers of potash.

The German companies, it is alleged, have their own exclusive selling agency in the United States, namely, the Potash Importing Corporation of America, New York city, with which they have agreed upon prices to be charged within the United States, and that the French companies have a similar agency for the distribution of their products in this country.

The petition charges that beginning May 1, 1927, the French and German companies have agreed to continue the division of the United States business and in addition to select a single exclusive selling agency with which they will agree upon the prices to be charged for potash in the United States.

Sixteen defendants were named in the complaint, among them the Deutsches Kalisyndikat & Gesellschaft, a German syndicate controlling potash in the German republic; the Societe Commerciale des Potasses d'Alsace, a French syndicate; the Potash Importing Corporation of America, with offices at 10 Bridge Street; Dr. Maximilien Kempner, Dr. Oskar Eckstein, A. Diehn, Robert Kunze and Dr. Ernst Frohnknecht German citizens, who are now staying at the Hotel Plaza; also E. K. Howe and H. A. Forbes, officers of the Potash Importing Corporation of Amercia.

About 1,000,000 tons of potash are used in the United States each year and of this amount 90 per cent is imported from Germany and France, it was said.

According to the Government's petition, which was for a permanent injunction or injunctions and such other relief as to the court might seem just and proper. German and French potash producing and exporting firms operated separately and independently from the World War period until 1924, when they formed the combination complained of.

Larger Output of Coal-Tar Dyes in 1926

PRELIMINARY figures compiled by the United States Tariff Commission show a domestic production of coal-tar dyes for 1926 of about 88,000,000 lb. with a value of about $37,000,000. This is an increase of 2 per cent by quantity over that of 1925. The total sales of dyes in 1926 were about 86,200,000 lb., valued at $36,300,000. This is an increase of 8.7 per cent by quantity and a decrease of 3 per cent in total value as compared with 1925. The increase in volume of sales is largely due to a slight improvement in the activity of the textile industry. The exports by quantity show practically no change from those of 1925.

In 1926 there was notable progress in the manufacture of specialty and fast dyes. Many new colors of high fastness were produced for the first time in this country during the year. The production of vat dyes established a new record in 1926, with a total of over 4,000,000 lb. as compared with 2,600,000 lb. in 1925. None of these dyes was made in the United States prior to the World War.

Ethylene Glycol Used in Dynamite Manufacture

GLYCERINE producers after having been conspicuously successful in stimulating the use of their product as an anti-freeze agent find themselves confronted with serious loss of market in the explosives field. Largely as a result of co-operative advertising the use of glycerine in this country was increased fifty per cent. The domestic industry, however, had to share the increase with importers as production in the United States was not sufficient to supply the country's requirements.

While glycerine was successfully invading a market which previously had been supplied by alcohol, ethylene glycol has competed with glycerine in the manufacture of dynamite. As 10,000,000 lb. of ethylene glycol was sold during the first year of its manufacture, there is every prospect of a steady increase in output. While imports will be displaced first, the substitute looms as a formidable competitor, with the possibility that the whole soap-making industry may be affected.

Sodium Sulphate Developed in Canada

A DEPOSIT of sodium sulphate near Palo on the Canadian National Railways transcontinental line west of Biggar, Saskatchewan, is being developed by the White Shore Chemical Co. of North Battleford. When a market has been established, a modern plant will be installed. The company has 1,500 acres under lease and hopes to increase this considerably. Another concern, the Sodium Sulphate Refining Co., Ltd., has been formed to develop sodium sulphate deposits located near Fusilier on the Canadia Pacific railway, west of Kerrobert, Saskatchewan.

German Wood Distillation Plants for Sale

CONSUL H. C. Claiborne, at Frankfort on the Main, reports that two German wood distilling plants located at Hochspeyer and Amoneburg are offered for sale by the Holzverkohlungs Industrie A. G. Both plants are fully equipped. This is the first concrete evidence of the adverse effect of the synthetic methanol on the German wood distilling industry.

Tariff Experts Complete Oil-Seeds Survey in China

A PARTY of four agricultural experts and accountants sent by the Tariff Commission to China to get figures on costs of producing cottonseed and peanuts arrived in the United States April 7, having completed the investigation of farm costs which are to be established in connection with the vegetable oils investigation. The same crew however is to be used immediately on an investigation of cherries in California so that their report on the oil-bearing seeds will not be submitted for several weeks.

The Tariff Commission agents encountered considerable difficulty in gathering cost data during the latter part of their work in China as their investigations were in the southern part of the Oriental republic and were hampered by the military activities there incident to the civil war. The work was completed before the disturbances of an anti-foreign nature became serious.

The Commission expects to complete its survey of costs of producing cottonseed, peanuts, and soya-beans in the fall and will apply the farm costs to the figures it has on hand as to factory costs of producing vegetable oils and will then revise its report on the oils and send it to the President. The vegetable oils case, resulting from an application by the Bureau of Raw Materials in behalf of industrial consumers for a reduction in duty under the flexible tariff, has been in progress more than three years.

Westport Mill of Dorr Co. Destroyed By Fire

FIRE totally destroyed the historic Westport mill and testing laboratory of the Dorr Co. on the Saugatuck River at Westport, Conn. on April 9. The mill was built during Revolutionary days when it was operated as a cotton mill. Later it was converted into a grist mill and finally bought by The Dorr Co. as a testing plant and laboratory. Temporary facilities for laboratory work have been set up in other buildings on the property, and resumption of semi-commercial testing will be delayed only until the mill can be rebuilt and equipped with new machinery.

Interest in Domestic Tung Oil Production

WHILE there is some doubt whether the shortage of China wood oil is chargeable principally to the war or to the monopolization of supplies by Chinese traders, the effect on consumers in this country is the same. One effect of the Chinese situation has been to cause consumers to take a more active interest in the development of tung oil production in Florida. More than 3,000 acres of trees are under cultivation there.

MEN *you should know about*

T. JABINE has resigned as New York district manager of the Merco Nordstrom Valve Co. and has joined the commercial division of the Central Hudson Gas and Electric Co.

B. N. GLICK, technical representative of the industrial Chemical Co., was married recently to Miss Alice Holmes.

JOHN E. TEEPLE has retired as vice-president and director of the American Potash & Chemical Corp. He will continue his connection with the organization as consulting chemical engineer.

CARL A. PHILIPPI, formerly associated with Dr. Colin G. Fink in electro-chemical research at Columbia University is now in the department of market studies of The Brown Co., Portland, Me.

DR. EDWARD M. HONAN of the Bell Telephone Laboratories, New York City, is spending a few weeks in California, at San Francisco and Los Angeles, supervising the installation of apparatus designed to prevent the corrosion of telephone cables.

L. H. BIGGARS, who has been located in the Los Angeles and Salt Lake offices of the Hardinge Co., has recently removed to the main office of the company at York, Pa., where he is to have charge of the clarifier and filtration work.

A. A. BACKHAUS of the U. S. Industrial Alcohol Co. has been spending a few weeks supervising some changes in the Anaheim, Calif., plant which the company has recently purchased.

M. C. WHITAKER has retired as president of the U. S. Industrial Chemical Co. and vice-president of the U. S. Industrial Alcohol Co. He will continue his connection with the organization as a director and as consulting chemical engineer.

KENNETH S. RITCHIE is now associated with Marland Oils, Ponca City, Okla., in the chemical section of the research department. He was awarded the degree of Doctor of Philosophy at Stanford University, last June.

WM. H. BAKER and C. G. SPENCER announce the organization of the firm of Baker and Spencer, Inc., for the general practice of engineering and construction at 117 Liberty Street, New York City.

DR. F. C. BROWN, who has been assistant director of the Bureau of Standards, has resigned this position to become acting director of the Museums of the Peaceful Arts. In his new work he will have headquarters at the Engineering Societies Building, 29 West 39th Street, New York City, where he is already located actively in charge of this endowed museum project.

EDWARD J. MEHREN

IN ORDER to give American industrialists and engineers first-hand information on the deliberations and conclusions of the International Economic Conference at Geneva, the McGraw-Hill Publishing Co., Inc., is sending EDWARD J. MEHREN, one of its vice-presidents, to the meeting. He will sail on the same ship with the American delegates and experts on April 20. Mr. Mehren will report his observations in *Chem. & Met.* He will also cover in articles in this paper summaries of the reviews, made at the conference, of the economic positions of the principal countries of the world.

CALENDAR

AMERICAN REFRACTORIES INSTITUTE, Spring meeting, Atlantic City, N. J., May 18 and 19.

AMERICAN ELECTROCHEMICAL SOCIETY, Philadelphia, April 27, 28 and 29.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, Cleveland, Ohio, May 31, June 1, 2, 3.

AMERICAN INSTITUTE OF CHEMISTS, annual meeting, N. Y., May 11.

AMERICAN LEATHER CHEMISTS ASSN., annual meeting, Cincinnati, Ohio, June 15, 16 and 17.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, spring meeting, White Sulphur Springs, W. Va., May 23 to 26.

CHAMBER OF COMMERCE OF THE UNITED STATES, fifteenth annual meeting, Washington, D. C., May 2-5.

NATIONAL ACADEMY OF SCIENCES, annual meeting, Washington, D. C., April 25, 26 and 27.

NATIONAL COLLOID SYMPOSIUM, Ann Arbor, Mich., June 22 to 24.

NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES, (11) Grand Central Palace, New York, Sept. 26—Oct. 1.

NATIONAL LIME ASSN., White Sulphur Springs, W. Va., May 17, 18 and 19.

J. J. WILLAMAN, of the department of agricultural biochemistry of the University of Minnesota, has been awarded a European fellowship by the International Education Board for the year 1927-1928. Dr. Willaman will work principally at the Imperial College of Science and Technology, in London, on the relation of the pectic enzymes of fungi to the pectin components of the host plants.

DR. ERICH W. SCHWARTZE has been appointed to the senior incumbency of the multiple industrial fellowship on cooking utensils in the Mellon Institute for Industrial Research. From 1916 to 1926 Dr. Schwartze was associate pharmacologist, in charge of pharmacological investigations in the Bureau of Chemistry.

SIDNEY D. KIRKPATRICK, associate editor of *Chem. & Met.*, is making a tour of some of the important industrial centers in the South. He will visit Richmond, Va., Charleston, W. Va., Greensboro and Charlotte, N. C., Greenville, S. C., Atlanta and Savannah, Ga., Birmingham, Ala., Laurel, Miss., New Orleans, La., Memphis, Nashville and Johnson City, Tenn., returning to New York about May 15.

OBITUARY

DR. FREDERICK BELDING POWER, internationally known chemist and for the past ten years head of the phytochemical laboratory of the Bureau of Chemistry, Department of Agriculture, died March 26, at his residence in Washington, D. C. Dr. Power was born 74 years ago at Hudson, N. Y. He was educated at Hudson Academy, the Philadelphia College of Pharmacy, National School of Elocution and Oratory at Philadelphia, and the University of Strassburg, Germany, where the degrees of Ph.G. and Ph.D. were conferred upon him. The honorary degree of LL.D. was conferred upon him by the University of Virginia.

HENRY R. CURME, 31 years old, president of the Savell Sayer Co. of Niagara Falls, was instantly killed on March 17 by the explosion of a tank of carbon monoxide in the yard of the company's plant at Lewiston Road, a short distance north of the city of Niagara Falls. The cause of the explosion has not been determined. Dr. Curme had climbed to the top of the tank to adjust an escape valve. The tank on which he stood was hurled 50 ft. in the air, and the young chemist's body was blown through the network of steel above the tank. He graduated with honors from Northwestern University where he took his A.B. degree and received his M.A. degree in the University of Chicago, later taking the degree of Doctor of Philosophy at the University of Pittsburgh, Pa. For a number of years he was associated with the chemical laboratories of the Union Carbide Co. of Charleston, W. Va.

MARKET CONDITIONS *and* PRICE TRENDS

Large Movement of Chemicals To Consuming Trades

THE PERIODS of transition through which some branches of the chemical industry have been passing, have not run this course and a feeling of unsettlement pervades the market. First among these groups may be mentioned the wood distillation chemicals. In the last few months Germany has been shipping large amounts of pure methanol to this country and sellers of the domestic product have been forced to grant price concessions in order to interest buyers. This is regarded as proof that the increase in import duty on methanol granted last year was not sufficient to protect domestic producers. Of later development was the report that a domestic plant after extensive experimental work had perfected a process for the manufacture of synthetic methanol. This plant is now producing on a commercial scale and is said to be capable of turning out a supply sufficient to satisfy all consuming needs of the country. There is uncertainty therefore relative to future production of pure methanol through wood distillation, to future activities of German shippers of methanol and to future progress of domestic production of synthetic methanol.

Ammonia Prices Unsettled

The ammonia situation also has failed to clarify itself and opinions differ regarding the recovery of value for aqua and anhydrous. In some quarters it is maintained that the low prices which have prevailed in recent months, were the result of competitive struggles to obtain market supremacy. With the establishment of some factors and the elimination of others, it is held that higher prices will follow. Such action, however, is far from certain as production of synthetic ammonia promises to be large in the future and it is even possible that the period of competitive selling has not yet reached its limits. The prospects, for the immediate future at least, seem to be unfavorable for any rise in prices for the ammonia products.

Chem. & Met. Weighted Index of Chemical Prices

Base = 100 for 1913-14

This month	**113.34**
Last month	113.09
April, 1926	113.25
April, 1925	112.60

A sharp advance in asking prices for denatured alcohol was the outstanding price development of the month. Basic chemicals are steady in price with fractional changes in some of the minor selections. The index number closed at an advance over March.

The situation surrounding the nitrogen supply for fertilizer purposes is another cause for market unsettlement. To date this has been more an external than a domestic problem. Synthetic nitrates have made rapid progress in European countries and the Chilean nitrate industry has retrograded in a proportionate way. With improved processes of production, costs of natural nitrates may be reduced to a point where they can compete favorably with synthetic nitrates but a fight for market control seems inevitable.

Production and consumption of chemicals has been maintained on a high plane. Alkalies have been moving practically up to the unusually high standards of last year. Some of the minor chemicals have sold in larger volume than they did last year. Fertilizer chemicals, while showing marked improvement in the last month, have found a narrower market for the year to date than was the case in the corresponding period of 1926. In the last month there has been a falling off in buying orders from the glass, paper and pulp, and tire industries. On the other hand there has been a seasonal increase in demand for insecticide chemicals and active buying is expected to continue for such selections as copper sulphate, copper carbonate, and possibly arsenic. Arsenic demand will vary according to the market for calcium arsenate. Preliminary reports are that heavy infestations of boll weevil may be expected in Texas and some of the other cotton-growing states.

Consumption of chemicals in the various industries may be shown relatively by the state of activity within those industries. Taking as a basis the weighted index of employment as prepared by the Bureau of Labor, activity in the trades which are large consumers of chemicals, shows the following for the months enumerated:

Weighted Index of Employment

	Feb. 1927	Jan. 1927	Feb. 1926
Dyeing and finishing textiles	99.4	98.2	101.4
Leather	94.7	93.0	93.3
Paper and pulp	94.4	94.4	95.3
Chemicals	96.3	96.1	95.3
Fertilizers	105.7	97.0	122.2
Glass	94.7	89.7	97.2
Automobile tires	104.3	102.4	113.7
Petroleum refining	102.4	101.9	98.0

Raw Materials Output

According to data compiled by the Department of Commerce, the output of raw materials in February was smaller than in January but greater than a year ago. Manufacturing production, after adjustment for differences in working time, was greater than in January, but showed a decline from February, 1926. As compared with last year, all industrial groups showed smaller output except textiles, leather, chemicals and oils, stone and clay products, and tobacco, which increased.

Stocks of commodities held at the end of February, after adjustment for seasonal variation, were greater than in either the previous month or February a year earlier, the increase over the preceding month being solely due to larger holdings of raw foodstuffs, other groups either declining or showing no change. As compared with last year, all groups of commodities were held in larger quantities, except manufactured foodstuffs which showed no change.

Unfilled orders for manufactured commodities, principally iron and steel and building materials, showed an increase over the previous month, an advance in building materials being more than sufficient to offset a decline in iron and steel. As compared with last year, the index of unfilled orders was lower, each subgroup showing the same general trend.

Price Movement

With large consumers covered ahead on contracts, spot trading in the more important chemicals has not been heavy enough to cause any price disturbance. Other price factors also are negligible, so there is no definite trend to values. Selling pressure is noted in some selections but generally speaking the market has been steady throughout the month. Oils and fats have shown a declining tendency which may continue over the present quarter. The most important factor in reducing the price level for oils is found in the large stocks of cottonseed oil held in this country. If preliminary reports show another large cotton acreage this season, further declines in value for oil are almost sure to follow. On the other hand China wood oil has been affected by the disturbances in China and record prices have been paid in the spot market.

Chem. & Met. Weighted Index of Prices for Oils and Fats

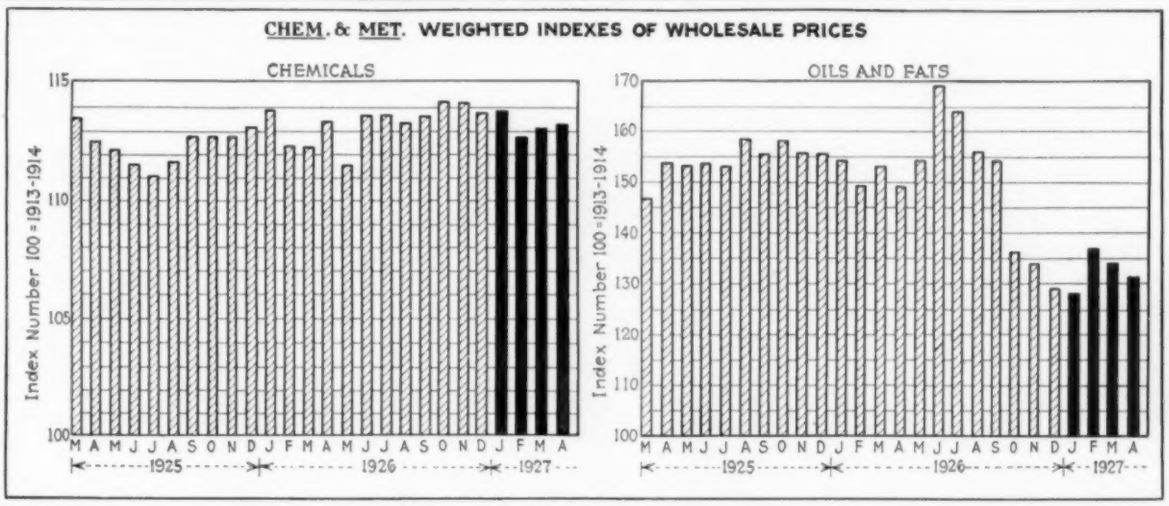
Base = 100 for 1913-14

This month	**131.67**
Last month	134.38
April, 1926	149.09
April, 1925	154.01

China wood oil has maintained a strong position throughout the month but lower prices were in effect on crude cottonseed, coconut, corn, and oleo oils. Glycerine also was lower and the index number declined accordingly.

CHEM. & MET. STATISTICS OF BUSINESS

IN THE CHEMICAL ENGINEERING INDUSTRIES


CHEM. & MET. WEIGHTED INDEXES OF WHOLESALE PRICES
CHEMICALS
OILS AND FATS
Index Number 100 = 1913-1914
M A M J J A S O N D J F M A M J J A S O N D J F M A
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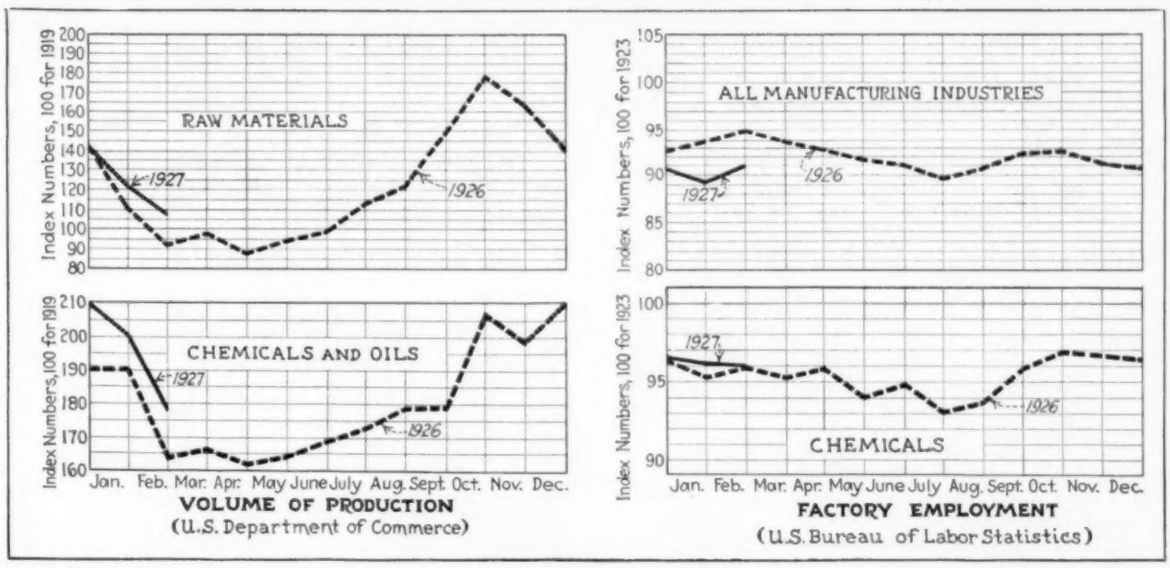

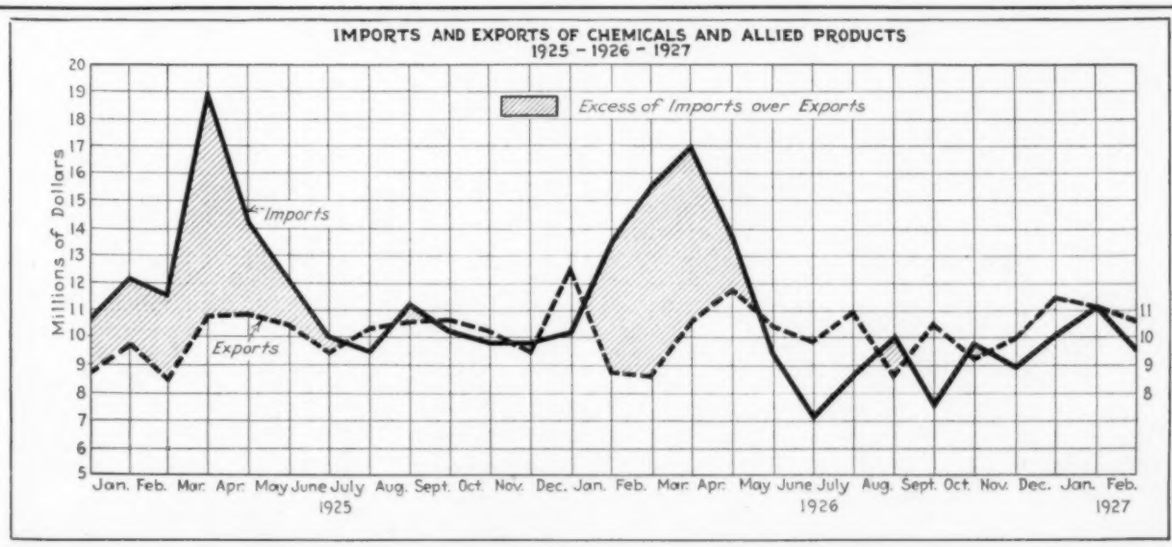
IMPORTS AND EXPORTS OF CHEMICALS AND ALLIED PRODUCTS
1925 - 1926 - 1927
Excess of Imports over Exports
Imports
Exports
Millions of Dollars
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb.
1925
1926
1927

Twenty-five Year Review of Chemical Prices

A REVIEW of prices for chemicals and related products in the twenty-five year period from 1902 to 1927, reveals many interesting developments. In the first place the weighted index number for chemicals, in April 1902, would work out at 117.42 as compared with 113.34 for April, 1927. The comparison over the span of years must allow for changes in processes if the index numbers are to carry significance. For instance in the 1902 computation, sulphuric acid 66 deg. was quoted at $28 per ton which was out of proportion to the quotations for 50 deg. acid. As a matter of fact most of the important chemicals were selling on a lower basis 25 years ago than they are at present. Sulphur offers one of the exceptions to the rule as it was held at $22.50 per long ton, f.o.b. mines, in 1902. Bichromates are now quoted at about th same levels as they were 25 years ago and prussiate of soda shows a corresponding position. Lead and zinc pigments have increased materially in the period and the advance in the market for naval stores may be noted from the quotations of 46c. per gal. for turpentine and $1.72½ per bbl. for grade E rosin, which prevailed in April, 1902.

Comparison of Current Prices and Those of 1902

		Current Price	April 1902
Acid, acetic, 28%	cwt.	$3.38	$1.80
Oxalic,	lb.	.11	.04½
Sulphuric, 66 deg.,	ton	28.00	15.00
Muriatic, 18 deg	cwt.	.85	1.70
Nitric, 36 deg	lb.	.05	.04½
Tartaric	lb.	.31½	.27½
Bleaching powder	cwt.	2.00	1.60
Soda ash, light	cwt.	1.32½	.95
Caustic	cwt.	3.00	1.90
Bicarbonate	cwt.	2.00	1.00
Bichromate	lb.	.06½	.06½
Chlorate	lb.	.06½	.06½
Nitrate	cwt.	2.60	2.40
Prussiate	lb.	.11	.11
Potassium bichromate	lb.	.08½	.08½
Caustic	lb.	.07½	.05
Chlorate	lb.	.08½	.07½
Prussiate	lb.	.18½	.14
Alum, lump	lb.	.03½	.01½
Alumina sulphate	cwt.	1.40	1.37½
Arsenic, white	lb.	.03½	.03½
Copper sulphate	lb.	4.90	4.65
Calcium acetate	cwt.	3.50	1.30
Calcium chloride	ton	21.00	9.00
Sal ammoniac	lb.	.05½	.05½
Aniline oil	lb.	.15	.09½
Aniline salts	lb.	.24	.08½
Cottonseed oil, crude	lb.	.07½	.04½
Linseed oil	lb.	10.05	8.4
Palm oil, Lagos	lb.	.08½	.05½
Castor oil, No. 3	lb.	.13½	.11½
Coconut oil, bbl	lb.	.12	.07½
Rapeseed oil	gal.	.82	.68
Cod oil, Newfoundland	gal.	.63	.36
Menhaden oil, crude	gal.	.45	.28

Higher price levels for oils and fats have been universal in the quarter of a century. The weighted index number based on prices asked in April, 1902, would be 90.05 which compares with the current index of 131.67. In 1902, crude cottonseed oil sold at 34½c. per gal. and coconut oil in bbl. was offered at 7¼c. per lb. Crude menhaden oil was available at 28c. per gal. and Newfoundland cod oil was quoted as low as 36c. per gal.

In considering the trend of prices over the twenty-five year period, it becomes evident that very important influences have been at work to counteract the higher cost of raw materials, labor, fuel, etc. In other words improved methods of manufacture, mass production, utilization of waste products, and other factors have contributed to hold average values in close proximity to those which prevailed in 1902.

CURRENT PRICES *in the* NEW YORK MARKET

The following prices refer to round lots in the New York Market. Where it is the trade custom to sell f.o.b. works, quotations are given on that basis and are so designated. Prices are corrected to April 18.

Industrial Chemicals

		Current Price	Last Month	Last Year
Acetone, drums	lb.	$0.12 -$0.13	$0.12 -$0.13	$0.12 -$0.13
Acid, acetic, 28%, bbl.	cwt.	3.38 - 3.63	3.38 - 3.63	3.25 - 3.50
Boric, bbl.	lb.	.08½- .08¾	.08½- .08¾	.08¾- .11
Citric, kegs	lb.	.43½- .44¼	.43¼- .47	.45½- .47
Formic, bbl.	lb.	.10½- .11	.10¼- .11	.10 - .10½
Gallic, tech., bbl	lb.	.50 - .55	.50 - .55	.45 - .50
Hydrofluoric 30% carb.	lb.	.06 - .07	.06 - .07	.06 - .07
Lactic, 44%, tech., light, bbl	lb.	.13½- .14	.13½- .14	.13½- .14
22%, tech., light, bbl	lb.	.06½- .07	.06½- .07	.06½- .07
Muriatic, 18°, tanks	cwt.	.85 - .90	.85 - .90	.85 - .90
Nitric, 36°, carboys	cwt.	.05 - .05¼	.05 - .05¼	.05 - .05½
Oleum, tanks, wks.	ton	18.00 -20.00	18.00 -20.00	16.00- 17.00
Oxalic, crystals, bbl.	lb.	.11 - .11½	.11 - .11½	.10½- .1
Phosphoric, tech., c'bys	lb.	.07 - .07½	.07 - .07½	.07½- .08
Sulphuric, 60°, tanks	ton	10.50 -11.00	10.50 -11.00	9.50 -10.00
Tannic, tech., bbl	lb.	.35 - .40	.35 - .40	.45 - .50
Tartaric, powd., bbl	lb.	.33 - .34	.31½- .31	.27½- .30
Tungstic, bbl	lb.	1.00 - 1.20	1.00 - 1.20	1.00 - 1.20
Alcohol, ethyl, 190 p'f. U.S.P. bbl	gal.	4.92½- 5.00	4.90½- 5.00	4.75 - 4.85
Alcohol, Butyl, dr	lb.	20 - .20½	.20½- .21	.18½- .19
Denatured, 190 proof				
No. 1 special dr	gal.	.37½- .39½	.33 - .35	.30 -
No. 5, 188 proof, dr.	gal.	.37½- .39½	.33 - .35	.32 -
Alum, ammonia, lump, bbl	lb.	.03½- .04	.03½- .04	.03½- .04
Chrome, bbl	lb.	.05½- .05¾	.05½- .05¾	.05½- 06
Potash, lump, bbl	lb.	.02¾- .03¼	.02¾- .03¼	.02¾- 03¼
Aluminum sulphate, com., bags	cwt.	1.40 - 1.45	1.40 - 1.45	1.40 - 1.45
Iron free, bg	cwt.	2.00 - 2.10	2.00 - 2.10	2.40 - 2.45
Aqua ammonia, 26°, drums	lb.	.02¾- .03	.02¾- .03¼	.03¼- .04
Ammonia, anhydrous, cyl	lb.	.11 - .13	.11 - .15	13 - .15
Ammonium carbonate, powd. tech., casks	lb.	.10½- .14	10½- 14	.11 - .14
Sulphate, wks.	cwt.	2.45 -	2.50 -	2.85 -
Amylacetate tech., drums	gal.	2.15 - 2.20	2.15 - 2.20	1.80 - 1.90
Antimony Oxide, bbl.	lb.	.16½- .17	.16½- .17	.16 - .17
Arsenic, white, powd., bbl	lb.	.03½- .04¼	.03½- .04¼	.03½- .04¼
Red, powd., kegs	lb.	.10½- .11	.10½- .11	.12 - .12¼

		Current Price	Last Month	Last Year
Barium carbonate, bbl	ton	47.00 -50.00	47.00 -50.00	45.00 -47.00
Chloride, bbl.	ton	57.00 -62.00	60.00 -65.00	63.00 -65.00
Nitrate, cask	lb.	.07½- .08	.07½- 08¼	.07½- .08
Blanc fixe, dry, bbl	lb.	.04 - .04½	.04½- .04	.03½- .04
Bleaching powder, f.o.b., wks., drums	cwt.	2.00 - 2.10	2.00 - 2.10	2.00 - 2.10
Borax, bbl.	lb.	.04½- .04¾	.04¾- .05	.05 - .05½
Bromine, cs.	lb.	.45 - .47	.45 - .47	.45 - .47
Calcium acetate, bags	cwt.	3.50 -	3.50 -	3.25 - 3.50
Arsenate, dr.	lb.	.06½- .08	.06½- .07	.06 - .07
Carbide drums	lb.	.05½- .06	.05½- .06	.05½- .06
Chloride, fused, dr., wks.	ton	21.00 -	21.00 -	21.00 -
Phosphate, bbl.	lb.	.07 - .07½	.07 - .07½	.07 - .07½
Carbon bisulphide, drums	lb.	.05½- .06	.05½- .06	.05½- .06
Tetrachloride drums	lb.	.06½- .07	.06½- .06½	.06½- .07
Chlorine, liquid, tanks, wks.	lb.	.04 - .04½	.04 - .04½	.04 - .04½
Cylinders	lb.	.05½- .08	.05½- .08	.05½- .08
Cobalt oxide, cans	lb.	2.00 - 2.10	2.10 - 2.20	2.10 - 2.25
Copperas, bgs., f.o.b. wks.	ton	15.00 -16.00	16.00- 18.00	13.50 -14.00
Copper carbonate, bbl	lb.	.17 - .17½	.17 - .18	.17 - .18
Cyanide, tech., bbl.	lb.	.49 - .50	.49 - .50	.49 - .50
Sulphate, bbl.	cwt.	4.80 - 4.90	4.80 - 4.90	4.50 - 4.60
Cream of tartar, bbl.	lb.	.22 - .22½	.22 - .22½	.21 - .22
Epsom salt, dom., tech., bbl.	cwt.	1.75 - 2.15	1.75 - 2.00	1.75 - 2.00
Imp., tech., bags	cwt.	1.15 - 1.25	1.15 - 1.25	1.35 - 1.40
Ethyl acetate, 85% drums	gal.	.74 - .76	.74 - .76	.82 - .85
99%, dr.	gal.	.95 - .96	.95 - .96	1.03 - 1.08
Formaldehyde, 40%, bbl.	lb.	11½- .11½	.11½- .11½	.09 - .09½
Furfural, dr.	lb.	15 - 17½	.15 - .17½	.17½- .20
Fusel oil, crude, drums	gal.	1.35 - 1.40	1.40 - 1.50	1.40 - 1.50
Refined, dr	gal.	2.50 - 3.00	2.50 - 3.00	2.50 - 3.00
Glaubers salt, bags	cwt.	1.00 - 1.15	1.00 - 1.10	1.20 - 1.40
Glycerine, e.p., drums, extra	lb.	.26 - .26½	.27 - .27½	.24 - .25
Lead:				
White, basic carbonate, dry, casks	lb.	.09½-	.09½-	.10¾-
White, basic sulphate, sck.	lb.	.09½-	.09½-	.10 -
Red, dry, sck	lb.	.10½-	.10¾-	.12½-
Lead acetate, white crys., bbl.	lb.	.14½- .15	.14½- .15	.14½-
Lead arsenate, powd., bbl	lb.	.14 - .15	.14 - .15	.14½- .15
Lime, chem., bulk	ton	8.50 -	8.50 -	8.50 -
Litharge, pwd., csk	lb.	.10 -	.10½-	.11½-
Lithopone, bags	lb.	.05½- .06	.05½- .06	.06 - .06½
Magnesium carb., tech., bags	lb.	.07½- .08	.07½- .08	.06½- .07
Methanol, 95%, dr.	gal.	.83 - .85	.83 - .85	.55 - .58
97%, dr.	gal.	.85 - .90	.85 - .90	.57 - .62
Nickel salt, double, bbl.	lb.	.10 - .10½	.10 - .10½	.09 - .10
Single, bbl.	lb.	.10¼- .11	.10½- .11	.10 - .11
Orange mineral, csk.	lb.	.12½-	.13 -	.14 -
Phosphorus, red, cases	lb.	.62 - .65	.62 - .65	.68 - .70
Yellow, cases	lb.	.32 - .33	.32 - .34	.34 - .36
Potassium bichromate, casks	lb.	.08½- .08¾	.08½- .08½	.08½- .08¾
Carbonate, 80-85%, calc., csk.	lb	.05½- .06	.06 -	.06 - .06½
Chlorate, powd.	lb.	.08½- .09	.08½- .09	.08¾- .09
Cyanide, cs.	lb.	.55 - .57	.55 - .58	.52 - .54

Industrial Chemicals—Continued

	Current Price	Last Month	Last Year
First sorts, csk. lb.	$0.09 -$0.09½	$0.08¾-$0.09	$0.08½-$0.08½
Hydroxide(c'stic potash)dr. lb.	.07½- .07¾	.07½- .07¾	.07½- .07½
Muriate, 80% bgs. ton	36.40 -	36.40 -	34.90 -
Nitrate, bbl. lb.	.06 - .06½	.06 - .06½	.06 - .07½
Permanganate, drums. lb.	.14 - .15	.14 - .15	.14 - .15
Prussiate, yellow, casks. lb.	.18½- .19	.18½- .19	.18 - .18½
Sal ammoniac, white, casks. lb.	.05½- .06	.05½- .06½	.05½- .06
Salsoda, bbl. cwt.	.90 - .95	.90 - .95	1.10 - 1.20
Salt cake, bulk. ton	17.00 -18.00	17.00 -18.00	17.00 -19.00
Soda ash, light, 58%, bags, contract. cwt.	1.32½-	1.32½-	1.38 -
Dense, bags. cwt.	1.37½-	1.45 - 1.55	1.45 - 1.55
Soda, caustic, 76%, solid, drums, contract. cwt.	3.00 -	3.00 -	3.10 -
Acetate, works, bbl. lb.	.04½- .05½	.04½- .05	.04½- .05
Bicarbonate, bbl. cwt.	2.00 - 2.25	2.00 - 2.25	1.75 - 2.00
Bichromate, casks. lb.	.06½- .06¾	.06½- .06½	.06½- .06¾
Bisulphate, bulk. ton	5.00 - 5.50	5.00 - 5.50	6.00 - 7.00
Bisulphite, bbl. lb.	.03½- .04	.03½- .04	.04½- .04½
Chlorate, kegs. lb.	.06½- .06½	.06½- .06½	.06½- .06½
Chloride, tech. ton	12.00 -14.75	12.00- 14.75	12.00 -14.00
Cyanide, cases, dom. lb.	.18 - .22	.18 - .22	.19 - .22
Fluoride, bbl. lb.	.09½- .09¾	.09 - .09½	.09 - .09¾
Hyposulphite, bbl. lb.	2.50 - 3.00	2.50 - 3.00	.02½- .02½
Nitrate, bags. cwt.	2.65 -	2.65 -	2.70 -
Nitrite, casks. lb.	.08 - .08½	.08½- .09	.09 - .09½
Phosphate, dibasic, bbl. lb.	.03½- .03¾	.03½- .03¾	.03½- .03¾
Prussiate, yel. drums. lb.	.12 - .12½	.11 - .11½	.10½- .10¾
Silicate (30°, drums). cwt.	.75 - 1.15	.75 - 1.15	.75 - 1.15
Sulphide, fused, 60-62%,dr. lb.	.03½- .04	.03 - .03½	.02½- .03
Sulphite, crys., bbl. lb.	.03 - .03½	.03 - .03½	.02½- .03
Strontium nitrate, bbl. lb.	.08½- .09	.08½- .09	.09½- .10
Sulphur, crude at mine, bulk. ton	19.00 -	19.00 -	15.00 -17.00
Chloride, dr. lb.	.04 - .05	.04 - .05	.04 - .05
Dioxide, cyl. lb.	.09 - .10	.09 - .10	.08½- .09
Flour, bag. cwt.	2.70 - 3.00	2.70 - 3.00	2.25 - 2.35
Tin bichloride, bbl. lb.	.19½-	.20 -	.17½-
Oxide, bbl. lb.	.70 -	.70 -	.66 -
Crystals, bbl. lb.	.47 -	.47½-	.42½-
Zinc chloride, gran., bbl. lb.	.06½- .06¾	.07 - .08	.06 - .07½
Carbonate, bbl. lb.	.10 - .11	.11 - .11¼	.12 - .14
Cyanide, dr. lb.	.40 - .41	.40 - .41	.40 - .41
Dust, bbl. lb.	.10½- .11	.10 - .10½	.08 - .08½
Zinc oxide, lead free, bag. lb.	.06½-	.07½-	.07½-
5% lead sulphate, bags. lb.	.06½-	.07 -	.06½-
Sulphate, bbl. cwt.	3.00 - 3.10	2.75 - 3.00	3.50 - 3.75

Oils and Fats

	Current Price	Last Month	Last Year
Castor oil, No. 3, bbl. lb.	$0.14 -$0.14	$0.14 -$0.14½	$0.13 -$0.14
Chinawood oil, bbl. lb.	.32 -	.30 - .32	.11½- .11½
Coconut oil, Ceylon, tanks, N. Y. lb.	.08½-	.08½-	.09½-
Corn oil crude, tanks, (f.o.b. mill). lb.	.07½-	.08½-	.10½-
Cottonseed oil, crude (f.o.b. mill), tanks. lb.	.07½-	.07½-	.10½-
Linseed oil, raw, car lots, bbl. lb.	10.36 -	10.5 -	10.7 -
Palm, Lagos, casks. lb.	.07½- .09	.08½- .08½	.08½-
Niger, casks. lb.	.07½-	.07½- .08	.08½-
Palm Kernel, bbl. lb.	.09½-	.09½-	.10 - .10½
Peanut oil, crude, tanks(mill) lb.	.12½-	.12½-	.10 -
Perilla, bbl. lb.	-	-	.14½-
Rapeseed oil, refined, bbl. gal.	.80 - .82	.80 - .82	.90 - .92
Sesame, bbl. lb.	-	-	-
Soya bean tank (f.o.b. Coast) lb.	.10 -	.09½-	.10½-
Sulphur(olive foots), bbl. lb.	.09½-	.09½-	.08½-
Cod, Newfoundland, bbl. gal.	.63 - .66	.63 - .64	.64 - .65
Menhaden, light pressed,bbl. gal.	.60 - .62	.60 - .62	.69 - .71
Crude, tanks(f.o.b. factory) gal.	-	.45 -	.55 -
Whale, crude, tanks. lb.	-	-	-
Grease, yellow, loose. lb.	.06½-	.07½-	.08½- .08½
Oleo stearine. lb.	.09½-	.10½-	.11 -
Red oil, distilled, d.p. bbl. lb.	.09½- .10	.09½- .10	.11½- .11½
Tallow, extra, loose. lb.	.07½-	.07½-	.08½-

Coal-Tar Products

	Current Price	Last Month	Last Year
Alpha-naphthol, crude, bbl. lb.	$0.60 -$0.65	$0.60 -$0.65	$0.60 -$0.62
Refined, bbl. lb.	.85 - .90	.85 - .90	.85 - .90
Alpha-naphthylamine, bbl. lb.	.35 - .36	.35 - .36	.35 - .36
Aniline oil, drums, extra. lb.	.15 - .16	.16 - .16½	.17 - .17½
Aniline salts, bbl. lb.	.24 - .25	.22 - .24	.22 - .23
Anthracene, 80%, drums. lb.	.60 - .65	.60 - .65	.60 - .65
Benzaldehyde, U.S.P., dr. lb.	1.15 - 1.25	1.15 - 1.35	1.30 - 1.35
Benzidine base, bbl. lb.	.70 - .72	.70 - .75	.72 - .74
Benzoic acid, U.S.P., kgs. lb.	.58 - .60	.58 - .60	.56 - .60
Benzyl chloride, tech, dr. lb.	.25 - .26	.25 - .26	.35 - .36
Benzol, 90%, tanks, works. gal.	.24 - .25	.25 - .28	.24 - .25
Beta-naphthol, tech., drums. lb.	.22 - .24	.22 - .24	.24 - .25
Cresol, U.S.P., dr. lb.	.18 - .20	.18 - .20	.18 - .20
Cresylic acid, 97%, dr., wks. gal.	.61 - .62	.59 - .63	.60 - .65
Diethylaniline, dr. lb.	.58 - .60	.58 - .60	.59 - .61
Dinitrophenol, bbl. lb.	.31 - .35	.31 - .33	.35 - .38
Dinitrotoluen, bbl. lb.	.17 - .18	.17 - .18	.18 - .20
Dip oil, 25% dr. gal.	.28 - .30	.28 - .30	.26 - .28
Diphenylamine, bbl. lb.	.45 - .47	.48 - .50	.48 - .50
H-acid, bbl. lb.	.63 - .65	.63 - .65	.65 - .66
Naphthalene, flake, bbl. lb.	.04½- .05	.05½- .06	.06½- .07
Nitrobenzene, dr. lb.	.09 - .10	.09 - .10	.09 - .10
Para-nitraniline, bbl. lb.	.52 - .53	.45 - .50	.50 - .53
Para-nitrotoluine, bbl. lb.	.28 - .32	.28 - .32	.40 - .42
Phenol, U.S.P., drums. lb.	.17 - .19	.17 - .19	.22 - .24
Picric acid, bbl. lb.	.30 - .40	.30 - .40	.25 - .26
Pyridine, dr. lb.	3.00 -	3.00 -	3.90 - 4.00

Coal-Tar Products—Continued

	Current Price	Last Month	Last Year
R-salt, bbl. lb.	.47 - .50	.40 - .44	.50 - .55
Resorcinal, tech, kegs. lb.	1.30 - 1.35	1.35 - 1.40	1.30 - 1.40
Salicylic acid, tech., bbl. lb.	.30 - .32	.30 - .32	.32 - .33
Solvent naphtha, w.w.,tanks. gal.	.35 -	.35 -	.35 -
Tolidine, bbl. lb.	.95 - .95	.95 - .96	.90 - .95
Toluene, tanks, works. gal.	.35 -	.35 -	.26 -
Xylene, com., tanks. gal.	36 - .41	.36 - .41	.36 - .40

Ferro-Alloys

	Current Price	Last Month	Last Year
Ferrotitanium, 15-18%. ton	$200.00-	$200.00-	$200.00-
Ferrochromium, 1-2%. lb.	.23- .25	.23- .35	.23-
Ferromanganese, 78-82%. ton	100.00-	88.00-90.00	90.00-
Spiegeleisen, 19-21%. ton	36.00-37.00	36.00-37.00	33.00-34.00
Ferrosilicon, 10-12%. ton	33.00-38.00	33.00-38.00	33.00-38.00
Ferrotungsten, 70-80%. lb.	.98- 1.03	1.00- 1.05	1.14-
Ferro-uranium, 35-50%. lb.	4.50-	4.50-	4.50-
Ferrovanadium, 30-40%. lb.	3.15- 3.75	3.25- 4.00	3.25- 3.75

Non-Ferrous Metals

	Current Price	Last Month	Last Year
Copper, electrolytic. lb.	$0.13 -	$0.13½-	$0.14 -$0.14½
Aluminum, 96-99%. lb.	.26 - .28	.26 - .27	.27 - .28
Antimony, Chin. and Jap. lb.	.13½- .15	.14½-	.19½-
Nickel, 99% lb.	.35 -	.35 -	.34 -
Monel metal, blocks. lb.	.32 - .33	.32 - .33	.32 - .33
Tin, 5-ton lots, Straits. lb.	.68 -	.69½-	.62½-
Lead, New York, spot. lb.	7.15 -	7.65 -	.08½-
Zinc, New York, spot. lb.	6.72½-	7.10 -	.08 -
Silver, commercial. oz.	.56½-	.56½-	.65½-
Cadmium lb.	.60 -	.60 -	.60 -
Bismuth, ton lots. lb.	2.20 - 2.25	2.70 - 2.75	2.65 - 2.70
Cobalt lb.	2.50 -	2.50 -	2.50 - 3.00
Magnesium, ingots, 99%. lb.	.75 - .80	.75 - .80	.75 - .80
Platinum, ref. oz.	108.00-	108.00-	112.00-
Palladium, ref. oz.	59.00- 63.00	68.00- 69.00	78.00-
Mercury, flask. 75 lb.	104.00-	104.00-	87.00-
Tungsten powder. lb.	1.05- 1.15	1.05-	1.18-

Ores and Semi-finished Products

	Current Price	Last Month	Last Year
Bauxite, crushed, wks. ton	$5.50- $8.50	$5.50- $8.50	$5.50- $8.75
Chrome ore, c.f. post. ton	21.00- 24.00	21.00- 24.00	22.00- 23.00
Coke, fdry., f.o.b. ovens. ton	3.75- 4.25	3.75- 4.25	3.75- 4.25
Fluorspar, gravel, f.o.b. Ill. ton	18.00-	18.00-	18.00-
Ilmenite, 52% TiO_2, Va. lb.	.0⅜- .0½	.0⅜- .0½	.01½-
Manganese ore, 50% Mn., c.i.f. Atlantic Ports. unit	.36 - .38	.36 - .38	.40 - .42
Molybdenite, 85% MoS_2 per lb. MoS_2, N. Y. lb.	.48 - .50	.48 - .50	.65- .70
Monazite, 6% of ThO_2. ton	120.00-	120.00-	120.00-
Pyrites, Span. fines, c.i.f. unit	.13½-	.13½-	.13½-
Rutile, 94-96% TiO_2. lb.	.11 - .13	.11 - .13	.12 - .15
Tungsten, scheelite, 60% WO_3 and over. unit	11.25 -11.50	11.25 -11.50	12.50 -13.00
Vanadium ore, per lb. V_2O_5. lb.	.25 - .28	.25 - .30	.25 - .35
Zircon, 99%. lb.	.03 -	.03 -	.03 -

Miscellaneous

	Current Price	Last Month	Last Year
Barytes, grd., white, bbl. ton	$23.00-$25.00	$23.00-$25.00	$20.00-$22.00
Casein, tech., bbl. lb.	.15 - .16	.15 - .16	.13½- .14
China clay, dom.,f.o.b. mine ton	10.00 -20.00	10.00 -20.00	10.00 -20.00
Dry colors:			
Carbon gas, black (wks.) lb.	.08 - .08½	.08 - .08½	.08 - .08½
Prussian blue, bbl. lb.	.33 - .34	.33 - .34	.32 - .33
Ultramine blue, bbl. lb.	.08 - .35	.08 - .35	.08 - .35
Chrome green, bbl. lb.	.27 - .31	.28 - .30	.28 - .30
Carmine red, tins. lb.	5.00 - 5.10	5.00 - 5.10	5.10 - 5.35
Para toner. lb.	.80 - .90	.80 - .90	.90 - .95
Vermilion, English, bbl. lb.	1.50 - 1.55	1.50 - 1.55	1.45 - 1.50
Chrome yellow, C. P., bbl. lb.	.17 - .18	.17½- .18	.17½- .18
Feldspar, No. 1 (f.o.b. N. C.) ton	6.50 - 7.00	6.50 - 7.00	6.00 - 6.50
Graphite, Ceylon, lump, bbl. lb.	.08 - .09	.07 - .09½	.09 - .10
Gum copal, Congo, bags. lb.	.09½- .10	.09½- .10	.09½- .10
Manila, bags. lb.	.15 - .18	.15 - .16	.14 - .16
Damar, Batavia, cases. lb.	.25 - .25½	.25 - .26	.25 - .25½
Kauri, No. 1 cases. lb.	.55 - .57	.55 - .57	.58 - .62
Kieselguhr (f.o.b. N. Y.) ton	50.00 -55.00	50.00 -55.00	50.00 -55.00
Magnesite, calc. ton	44.00 -	44.00 -	38.00 -42.00
Pumice stone, lump, bbl. lb.	.05 - .07	.05 - .08	.04½- .06
Imported, casks. lb.	.03 - .40	.03 - .40	.03 - .35
Rosin, H. bbl.	11.00 -	11.62 -	14.50 -
Turpentine gal.	.68 -	.77 -	1.01 -
Shellac, orange, fine, bags. lb.	.38 - .39	.47 - .48	.40 - .41
Bleached, bonedry, bags. lb.	.47 - .50	.50 - .52	.43 - .44
T. N. bags. lb.	.37 - .38	.42 - .44	.32 - .34
Soapstone (f.o.b. Vt.), bags. ton	10.00 -12.00	10.00 -12.00	9.00 -11.00
Talc, 200 mesh (f.o.b. Vt.). ton	11.00 -	11.00 -	10.50 -
200 mesh (f.o.b. Ca.). ton	7.50 -10.00	7.50 -10.00	7.50 -11.00
325 mesh (f.o.b. N. Y.). ton	14.75 -	14.75 -	14.75 -
Wax, Bayberry, bbl. lb.	.25 - .26	.25 - .26	.20 - .21
Beeswax, ref., light. lb.	.45 - .46	.45 - .47	.46 - .47
Candelilla, bags. lb.	.33 - .34	.34 - .35	.36 - .37
Carnauba, No. 1, bags. lb.	.65 - .70	.70 - .72	.48 - .50
Paraffine, crude 105-110 m.p. lb.	.05½- .06	.06 - .06½	.05½- .06

PATENTS ISSUED
March 8 to 29, 1927

Petroleum Refining

Process of Converting Higher-Boiling Petroleum Hydrocarbons Into Lower-Boiling Petroleum Hydrocarbons. Charles B. Buerger, Pittsburgh, Pa., assignor to Gulf Refining Company, Pittsburgh, Pa. —1,623,025.

Method of Treating Petroleum. Roy Cross, Kansas City, Mo.—1,623,018.

Method and Apparatus for Treating Petroleum Hydrocarbons. Walter M. Cross, Kansas City, Mo.—1,621,475.

Process of Cracking Petroleum Oil. Gustav Egloff, Chicago, Ill., assignor to Universal Oil Products Company, Chicago, Ill.—1,619,921.

Process of Converting Oils and Apparatus Therefor. John Collins Clancy, Asbury Park, N. J.—1,620,075.

Apparatus for Cracking Oil. Gustav Egloff and Harry P. Benner, Chicago, Ill., assignors to Universal Oil Products Company, Chicago, Ill.—1,619,922.

Process for Converting or Cracking Hydrocarbon Oils. Walter Edwin Trent, Washington, D. C., assignor to Trent Process Corporation, New York, N. Y.—1,619,896.

Refining Oils. Harrison O. Parker, Tulsa, Okla., assignor to The Mathieson Alkali Works, New York, N. Y.—1,622,879.

Apparatus for Treating Crude Oils. Harry A. Hopkins, Taft, Calif.—1,621,782.

Process and Apparatus for Treating Oils. Lyman C. Huff, Chicago, Ill., assignor to Universal Oil Products Company, Chicago, Ill.—1,619,977.

Process of and Apparatus for Refining Petroleum. Frank A. Milliff and John A. Milliff, Los Angeles, Calif.—1,620,163.

Process of Separating Hydrocarbon Fractions. Daniel Pyzel, Piedmont, Calif., assignor to Simplex Refining Company, San Francisco, Calif.—1,622,737.

Apparatus for Condensing Oils. Charles B. Buerger, Pittsburgh, Pa., assignor to Gulf Refining Company, Pittsburgh, Pa.—1,622,941.

Apparatus for Treating Petroleum Oil. Hiram J. Halle, New York, N. Y., assignor to Universal Oil Products Company, Chicago, Ill.—1,619,929.

Apparatus for Heating Stills. George D. White, Port Arthur, Tex., assignor to The Texas Company, New York, N. Y.—1,621,298.

Art of Distillation. David Moyes Allan, Halifax, Nova Scotia, Canada, assignor to Standard Development Company.—1,621,229.

Process of Recovering Condensable Vapors from Gases. Harry H. Armstrong, Los Angeles, Calif.—1,621,821.

Still. Henry M. Lasher, Kansas City, Kans., assignor to The Kansas City Gasoline Company, Kansas City, Kans.—1,622,452.

Coking Still. Roy Cross, Kansas City, Mo., assignor to Gasoline Products Company, New York, N. Y.—1,622,573.

Method of Reactivating Desulphurizing Agents for Hydrocarbon Oils. James B. Rather, Brooklyn, and Frederick S. Shepard, New Rochelle, N. Y., assignors to Standard Oil Company of New York, New York, N. Y.—1,622,671.

Soluble Oil. Howard Dimmig, Chicago, Ill., assignor to The Texas Company, New York, N. Y.—1,621,483.

Organic Processes

Azo Dyestuffs Containing Chromium and Process of Making Same. Hans Gubler, Hermann Stahel, and Fritz Straub, Basel, Switzerland, assignors to The Firm Society of Chemical Industry in Basle, Basel, Switzerland.—1,623,005.

Manufacture of Azo Dyestuffs Derived from 2-Hydroxynaphthalene-3-Carboxylic-Acid-Arylamides. Hermann Wagner, Hochst-on-the-Main, Germany, assignor to I. G. Farbenindustrie Aktiengesellschaft, Frankfort-on-the-Main, Germany.—1,622,690.

Acylamino-Hydroxybenzene Arsine Oxides. Ludwig Benda, Mainkur, near Frankfort-on-the-Main, Germany, assignor to I. G. Farbenindustrie Aktiengesellschaft, Frankfort-on-the-Main, Germany.—1,622,271.

Process of Making 2-7 Dinitro-Anthraquinone. Berthold Stein, Elberfeld, Germany, assignor to Grasselli Dyestuff Corporation, New York, N. Y.—1,622,168.

Arsenical Solutions and Method of Preparing Same. Otto Lowy, Newark, N. J., assignor, by mesne assignments, to Steneck Trust Company, trustee, Hoboken, N. J.—1,621,121.

Process for the Manufacture of Hydrocyanic Acid. Wilhelm Gluud, Dortmund-Eving, Germany.—1,622,372.

N-Butyl Ethyl Barbituric Substance. Ernest H. Volwiler, Chicago, Ill., assignor to Abbott Laboratories, Chicago, Ill.—1,621,094.

Higher Aldehyde Derivatives of Reaction Products of Aldehydes and Amines and Process of Making Same. Clayton Olin North, Tallmadge Township, Summit County, Ohio.—1,619,953.

Process for Decomposing Fats or Oils Into Fatty Acids and Glycerin. Albert S. Richardson and Clinton V. Conley, Cincinnati, Ohio, assignors to The Procter & Gamble Company, Cincinnati, Ohio.—1,622,974.

Barbituric Acid and Process of Making Same. Friedrich Boedecker, Berlin-Dahlem, Germany, assignor to the Firm I. D. Riedel A. G., Berlin-Britz, Germany.—1,622,129.

Triazo-Nitrate Explosives and Process of Producing the Same. Frank H. Bergeim, Woodbury, N. J., assignor to E. I. du Pont de Nemours & Company, Wilmington, Del.—1,620,714.

Process of Making Organic Lead Compounds. Thomas Midgley, Jr., Dayton, Ohio, assignor, by mesne assignments, to General Motors Corporation, Detroit, Mich.—1,622,228.

Process of Producing Alkyl Compound of Lead. George Calingaert, Cambridge, Mass., assignor, by mesne assignments, to General Motors Corporation, Detroit, Mich.—1,622,233.

Treatment of Formates of Metals of the Alkali-Earth Group. Otto Paul Curt Bredt, Allentown, Pa., assignor to Trojan Powder Company, New York, N. Y.—1,622,991.

Inorganic Processes

Production of Phosphoric Acid. Herman A. Brassert, Chicago, and William H. Waggaman and Henry W. Easterwood, Chicago Heights, Ill., assignors to Victor Chemical Works, Chicago, Ill.—1,622,082.

Production of Phosphorus Pentoxide. Gustav Pistor, Bitterfeld, Germany, assignor to I. G. Farbenindustrie Aktiengesellschaft, Frankfort, Germany.—1,622,206.

Process for the Evolution of Hydrocyanic Acid. Hans Lehrecke, Frankfort-on-the-Main, Germany, assignor to The Roessler & Hasslacher Chemical Company, New York, N. Y.—1,620,365.

Gypsum Product and Method of Producing the Same. Layton M. Parkhurst, Indianapolis, Ind., assignor, by mesne assignments, to Federal Gypsum Products Company, Chicago, Ill.—1,620,915.

Process for the Treatment of Leucite and Other Sodium and Potassium Silicates with Lime for the Purpose of Exracting Potassium or Sodium and Aluminum Values. Félix Jourdan, Rome, Italy.—1,620,212.

Manufacture of Fertilizers. George Claude, Paris, France, assignor to Societe l'Air Liquide (Societe Anonyme pour Georges Claude), Paris, France.—1,621,311.

Process of Producing Metallic Oxides. George B. Filmer, Toronto, Ontario, Canada, assignor of one-half to Walter James Harvey, Toronto, Ontario, Canada.—1,620,880.

Process of Recovering Vanadium. Karl B. Thews, Sawpit, Colo., assignor to Colorado Vanadium Corporation, New York, N. Y.—1,621,038.

Chemical Engineering Equipment and Processes

Pulverizing Machine. William K. Liggett, Columbus, Ohio, assignor to The Jeffrey Manufacturing Company, Columbus, Ohio.—1,621,938.

Pulverizer. Henri Emil Witz, Rheinland Baden, Germany, assignor to The Babcock & Wilcox Company, Bayonne, N. J.—1,621,571.

Process of and Apparatus for Obtaining Powders of Great Fineness. Emil Podszus, Berlin-Friedrichshafen, Germany.—1,621,-270.

Evaporator. Ira Merlis, New York, N. Y., assignor to Kelvin Engineering Co., Inc., New York, N. Y.—1,622,918.

Distilling Apparatus. Walter E. Brown, Kansas City, Mo., assignor to United Iron Works, Inc., Kansas City, Mo.—1,620,593.

Method of Distillation. John Stanley Morgan, London, England, assignor to Thermal Industrial and Chemical (T. I. C.) Research Company Limited, London, England.—1,622,964.

Process for the Separation of the Constituents of Gaseous Mixtures Such as Those Containing Hydrogen. Georges Claude, Paris, France, assignor, by mesne assignments, to Lazote, Inc.—1,620,192.

Filter Press. Angelo M. Capra, Philadelphia, Pa., assignor, by mesne assignments, to Capra Filter Press Corporation.—1,621,767.

Process of Reactivating Purifying Agents. Paul Mahler, New York, N. Y., assignor to Darco Sales Corporation, New York, N. Y.—1,617,533.

Manufacture of Vegetable Carbon. Leonard Hugh Bonnard, London, England, assignor of one-half to Alfred Henry Bonnard, London, England.—1,619,649.

Process of Recovering Adsorbed Material from Adsorptive Material. Georg Müller, Frankfort-on-the-Main, Germany, assignor to American Lurgi Corporation, New York, N. Y.—1,617,960.

Method and Apparatus for the Manufacture of Carbon Black or Lamp-Black. Elmer B. Bird, Little Rock, Ark., assignor of fifty-one one-hundredths to J. W. Trieschmann, Little Rock, Ark.—1,616,409.

Carbon Black and Process and Apparatus for Producing Same. Chauncey Matlock, Brooklyn, N. Y., assignor to Monroe-Louisiana Carbon Company, Monroe, La.—1,617,071.

Method of Chlorinating Solutions. James H. MacMahon, Niagara Falls, N. Y., assignor to The Mathieson Alkali Works, Inc., New York, N. Y.—1,616,134.

Process for Extracting Fatty Acids from Oils and Fats. Karl Friedrich Wilhelm, Stralsund, Germany.—1,616,292.

Process for the Treatment of Oleaginous Seeds or Oleaginous Vegetable Substances for the Purpose of Extracting the Oil Contained Therein. Georges Kammermann, Paris, France.—1,616,319.

Drying and Polymerizing Oil and Method of Making Same. John J. Kessler, St. Louis, Mo.—1,616,321.

Gas-Absorption Apparatus. Max Mauran, Niagara Falls, N. Y., assignor to The Mathieson Alkali Works, Inc., New York, N. Y.—1,619,430.

Distilling and Refluxing Unit. Harry H. Armstrong, Los Angeles, Calif.—1,616,840.

Apparatus for Separating the Constituents of Gaseous Mixtures. Claude C. Van Nuys, Cranford, N. J., assignor to Air Reduction Company, Incorporated, New York, N. Y.—1,619,169.

Sectional Condenser. Joseph Price, New York, N. Y., assignor to the Griscom-Russell Company, New York, N. Y.—1,619,034.

Apparatus for Separating Liquids of Different Specific Gravity. Thomas Fisher, Philadelphia, Pa.—1,618,151.

Method of Measuring the Rate of Flow of Liquid. Charles M. Allen, Worcester, Mass.—1,616,481.

Deaerating Water. George H. Gibson, Upper Montclair, N. J., assignor to Cochrane Corporation, Philadelphia, Pa.—1,618,424.

High - Temperature - Heating Method. Crosby Field, New York, N. Y., assignor to Chemical Machinery Corporation.—1,619,660.

Magnetic Temperature-Control System, James C. Woodson, East Pittsburgh, Pa., assignor to Westinghouse Electric & Manufacturing Company.—1,617,360.

Automatic Temperature-Controlling Apparatus. Thomas Loftus Jones, Christchurch, New Zealand.—1,618,828.

Apparatus for Heating and for Controlling Reactions at High Temperatures. Crosby Field, Yonkers, N. Y., assignor to Chemical Machinery Corporation.—1,619,663.

Clarifying and Purifying Liquids and Waste Waters. Andreas Johan Ravnestad, Fredriksstad, Norway.—1,619,036.

Process of Rendering Iron and Steel Nonoxidizable and Articles Produced Thereby. Edward G. Caughey, Sewickley, Pa., assignor to Edgewater Steel Company, Pittsburgh, Pa.—1,617,616.

Drier. Charles H. Greenwood, La Salle, N. Y., assignor to The Carborundum Company, Niagara Falls, N. Y.—1,615,222.

Catalytic Apparatus. Francis Herbert Bramwell, Hartford, England, assignor to Atmospheric Nitrogen Corporation, Solvay, N. Y.—1,618,265.

Absorbent Decolorizing Medium. Charles B. Davis, New York, N. Y.—1,618,149.

Process and Apparatus for the Removal of Oil from Condensation Waters. Jean Baptiste Gail and Noël Adam, Paris, France.—1,617,208.

Process for Removing the Dust From Calcium Cyanamide and Deodorizing the Same. Joseph Breslauer, Geneva, Switzerland, assignor to Compagnie de L'Azote et des Fertilisants S. A., Geneva, Switzerland.—1,619,185.